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A TREATISE

ON THE

LAW OF ELECTRIC LIGHTING.

WITH

THE ACTS OF PARLIAMENT,

AND RULES AND ORDERS OF THE BOARD OF TRADE, A MODEL
PROVISIONAL ORDER,

AND

A SET OF FORMS.

TO WHICH IS ADDED
A DESCRIPTION OF THE PRINCIPAL APPARATUS USED IN
ELECTRIC LIGHTING, WITH ILLUSTRATIONS.

BY

(Hardinge Samuel)

HENRY CUNYNGHAME, BARRISTER-AT-LAW,

LATE ROYAL ENGINEERS.

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PREFACE.

THIS book consists of a short introduction, together with the Electric Lighting Act, 1882, and the incorporated statutes then follow. I have not reprinted or commented on the Lands Clauses Acts, nor the Acts enabling the local authorities to levy rates and borrow money, as these general powers have been well treated in other books, and would have taken up too much space. The October Rules of the Board of Trade, the model Proofs, the Memorandum of February 26th, and a specimen of one of the Provisional Orders lately issued by the Board of Trade, next follows. Then are inserted some specimens of forms most likely to be useful.

The notes on Electricity at the end were at first divided up among the different sections. I subsequently thought it best to separate them. Without pretending to compete with more elaborate works I hope they may be found useful. They have not been compiled from books, but are the result in every case of an examination of the actual apparatus. The illustrations are original, with the exception of those of the machines which, (with the kind permission of Mr. Dredge) are taken from his large and beautiful work on Electric Lighting.

HENRY CUNYNGHAME.

2, PAPER BUILDINGS, TEMPLE,
April, 1883.

ERRATA.

Page 134. Line 35, for "fusible," read "fusible plug."

Page 190. The words "in the direction P, B, N, C, Q, and in the reverse direction as the coils move in the direction Q, C, S, D, P," should be "in the direction B, N, C, and in the reverse direction, as the coils move in the direction D, S, E."

Page 211. The lines of force proceeding across the Gramme ring in Fig. 31 ought to have been drawn at right angles to their present position; for they are the resultant of the poles N and S, and of those at P and Q. They therefore cross the ring at points between N and Q, P and S respectively.

TABLE OF CONTENTS.

PAGE

INTRODUCTION—Sec. 1 . . . .
Sec. 2. The nature of Provisional Orders and Licenses . . . 4
Sec. 3. Procedure in obtaining Provisional Orders and Licenses . . 6

THE ELECTRIC LIGHTING ACT, 1882 (45 and 46 Vict. cap 56) . . 15

SECTION
1. Short title 15
2. Application of Act 15
3. Granting of licenses authorising the supply of electricity . . . 16
4. Granting of Provisional Orders authorising the supply of electricity . 18
5. Making of rules as to application, &c., under Act 19
6. Regulations to be inserted in licenses, &c. 20
7. Expenses of local authority 21
8. Power of local authority to borrow money 22
9. Accounts 23
10. General powers of undertakers under License or Provisional Order . . 23
11. Power for local authority to contract in certain cases and restrictions on assignments of powers, &c., of undertakers 23
12. Incorporation of certain provisions of Clauses Consolidation Acts . 24
13. Restriction on breaking up of private streets, railways, and tramways . 27
14. Restrictions as to above-ground works 27
15. Power to undertakers to alter position of pipes and wires . . . 28
16. Clause for protection of canals 28
17. Compensation for damage 29
18. Undertakers not to prescribe special form of lamp or burner . . 29
19. Obligation on undertakers to supply electricity 30
20. Charges for electricity 30
21. Recovery of charges, &c. 31
22. Injuring works with intent to cut off supply of electricity . . 31
23. Stealing electricity 31
24. Power to enter lands or premises for ascertaining quantities of electricity consumed, or to remove fittings, &c. 32
25. Electric lines, &c., not to be subject to distress in certain cases . . 33
26. Provision for protection of the Postmaster-General 33
27. Purchase of undertaking by local authority 35

SECTION PAGE
28. Arbitration 36
29. Power of Board of Trade to relieve gas undertakers from obligation to supply gas in certain cases 37
30. Annual report by Board of Trade 37
31. Definition of local authority, &c. 38
32. Interpretation 38
33. For the protection of mines 38
34. Provision as to general Acts 39
35. Saving for privileges of Postmaster-General 39

As to Scotland.

36. Application of Act to Scotland 39

As to Ireland.

37. Application of Act to Ireland 39
Schedule 41

ACTS INCORPORATED WITH THE ELECTRIC LIGHTING ACT, 1882.

GASWORKS CLAUSES ACT, 1847 (10 Vict. c. 15).

6. Power to break up streets 49
7. Not to enter private land 50
8. Notices to be served 54
9. Superintendence 55
10. Reinstatement 55
11. Penalties for delay 55
12. In case of delay, owners, &c., may reinstate 56
13. Supply of gas 56
14. Power to let meters. 56
15. Power to enter buildings to ascertain gas consumed 57
16. Recovery of gas rents 57
17. Removal of gas pipes when supply discontinued 57
18. Fraudulent use of gas 58
19. Wilful damage to gas pipes 58
20. Satisfaction for accidents 59
40. Incorporation of Railway Clauses Act, 1845 59

GASWORKS CLAUSES ACT, 1871 (34 & 35 Vict. c. 41).

38. Penalty for injuring meters 60
39. Incoming tenants not liable for arrears 61
40. Recovery of gas rents 61
41. Recovery of sums due to undertakers 61
42. Contents of summons or warrant 61
43. Service of notices by undertakers 61
44. Qualification of Justices 62

THE BOARD OF TRADE ARBITRATIONS ACT (37 & 38 Vict. c. 40).

1. Title 62
2. Board of Trade inquiries 62
3. Expenses of arbitrations 63
4. Meaning of "Special Act" 63
5. Repeal of Board of Trade Inquiries Act, 1872 64

SECTION PAGE
6. Railway Commissioners may be arbitrators 64
7. Their powers 64
8. Regulation of Railways Act, 1873, incorporated 64

TELEGRAPH ACT, 1878 (41 & 42 VICT. c. 78).

1. Title 65
2. Definitions 65
7. Alterations in telegraph lines by works done in pursuance of special Acts 66
8. Compensation 68
9. Penalty for obstruction 69
10. Prosecution of offence 69
11. Provision as to Postmaster-General 70

NOTE ON THE LANDS CLAUSES ACTS 72

NOTE ON THE PUBLIC HEALTH ACTS 72

NOTE ON THE METROPOLIS MANAGEMENT ACT, 1855 . . 73

NOTE ON THE LOCAL LOANS ACT, 1875 74

OFFICIAL DOCUMENTS OF THE BOARD OF TRADE:
The October Rules 75
Form of proofs for licenses 81
Form of Proofs for Provisional Orders 88
Memorandum of Board of Trade, Feb. 26th 94
Chelsea Electrical Lighting Provisional Order 98

(The Table of Contents of the Order is printed at page 98.)

FORMS—
1. Notice to Local Authority of intention to apply for a Provisional Order 153
2. Notice convening a meeting 153
3. Resolution of local authority 154
4. Advertisement in newspapers 154
5. Memorial 156
6. Statement of local authorities in whose area the area of supply will be situate 157
7. Streets, &c., proposed to be broken up 157
8. Canals, &c., to be crossed 157
9. Capital to be employed 157
10. Certificate of passing of resolution 157

PART II.

CHAP. I. ELEMENTARY PRINCIPLES.
Sec. 1. Magnetism 159
Sec. 2. Electricity 166
Sec. 3. The production of electricity 170
Sec. 4. Electro-magnetism 178
CHAP. II.
Sec. 1. On dynamos in general 196

CHAP. II. PAGE
Sec. 2. On pole-armature machines 205
The Lontin machine 205
The Gordon dynamo 206
Sec. 3. On ring-armature machines 209
The Gramme machine 214
The Brush machine 219
The Bürgin-Crompton machine 222
The Maxim machine 226
The Weston machine 226
The Gülcher machine 227
The Schückert machine 228
Sec. 4. Drum-armature machines 229
The Siemens' machine 229
The Edison machine 232
The Ferranti-Thompson machine 234
The Elphinstone Vincent machine 236
CHAP. III. ELECTRIC LAMPS 237
Sec. 1. Arc lights 237
Sec. 2. Incandescent lamps 240
Swan 244
Edison 245
Maxim-Weston 247
Lane-Fox 247
Woodhouse and Rawson 248
CHAP. IV. ON CONDUCTORS 250
Safety plugs 253
CHAP. V. ON ELECTRO-MOTORS 254
Siemens' Tramway 255
CHAP. VI. ELECTRIC METERS 257
Sec. 1. Chemical deposition meters—Edison 258
Sec. 2. Mechanical Meters 259
Galvanometers: — Sir W. Thompson—Marcel-Deprez—Ayrton and Perry—Siemens 261
Volt-meters 261
Boys' meters 263
Hopkinson's meter 266
Ayrton and Perry's energy meter 268
CHAP. VII. THE COST OF ELECTRIC LIGHTING . . . 270
CHAP. VIII. STORAGE BATTERIES OR ACCUMULATORS . . 275
Faure-Sellon-Volckmar 276
Kabath 277
CHAP. IX. GAULARD AND GIBBS' INDUCTION COILS . . 278

APPENDIX, on Units of Electrical Measurement 279

INTRODUCTION.

SEC. 1.

Introduction.

THE electrical mania of 1882 has passed, and though the over-sanguine views then prevalent have been modified, enough has been done to show that electric lighting is possible at such cost as is likely to cause an extensive demand.

The labours of the Parliamentary Committee of 1882, **Page 75.** resulted in the Electric Lighting Act, 1882 (45 and 46 Vict. c. 56); in the October Rules of the Board of Trade, made under the powers of the Act, and the memorandum of the **Page 97.** Board of Trade, dated February 26th, 1883. The Board of Trade has also drawn up two forms or schemes of the proof **Pages 81 and 88.** required by them, that the requirements necessary to the obtaining of licenses and orders have been duly complied with, and has just issued the first of its provisional orders, which, it is understood, is to serve as the model for orders and licenses in **Page 15** future. These, together with the Act itself, and the Acts incorporated therewith, form the present law on the subject. It may, however, be expected that the Board of Trade and the local **Page 20.** authorities will, under the powers given them, issue from time to time such regulations with regard to safety as they may deem requisite.

The private supply of electricity is unfettered by these Acts and rules, which only affect the action of those who seek for compulsory powers. The Act gives no power to "undertakers" **Pages 53 and 107.** to interfere with private property or roads not dedicated to the public, or over which the public have no rights.

The persons who will probably require these compulsory powers, and who are styled "undertakers," are the various local **Page 41.** authorities (see the schedule to the Electric Lighting Act, 1882), and private firms and companies.

The Act points out three ways of obtaining these powers: First, by special Act. Several such special Acts were passed before the Electric Lighting Act, 1882; but, except in peculiar cases, it does not seem probable that more of the same kind will

Introduction.

be passed. If they are, then by the provisions of sec. 2 of the Electric Lighting Act, 1882, the Electric Lighting Act, 1882, will apply to them, except where such application is negatived, either expressly or by plain intention.

The next method is by license. Licenses may be granted by the Board of Trade to the local authority of the district, or with the consent of that local authority, to the local authority of any other district, or to a company or private firm. A license lasts for seven years, but is renewable. When obtained it has almost exactly the same effect as a private Act, the undertakers being, however, subject to such regulations and bye-laws as may be made for public safety by the Board of Trade and the local (1883). authority. [This session there have been applications for about thirty provisional orders by local authorities, four licenses, and about sixty more provisional orders by companies and private firms.]

The third method is by a provisional order. This requires no consent of the local authority of the district, though if they oppose, it would be perhaps difficult to obtain. It will generally Page 75. be preferentially granted to the local authority (Rule II.) and does not come into force until confirmed by Bill in Parliament. But when obtained it may be for any period, subject however to this proviso (as is also a power under any special Act), that at the end of twenty-one years after it is granted, and also at the end of every succeeding seven years, the local authority may take over the concern at the simple market value of the land Page 35. and plant and engines, nothing being allowed for goodwill (Electric Lighting Act, sec. 27). This provision is a very severe one, and it is to be feared will discourage undertakers other than the local authorities of the districts. For, to risk all the chances of failure, with only a period of twenty-one years for success, is a somewhat hazardous venture.*

Neither the license nor the provisional order when granted is exclusive or creates any monopoly, though it is natural to suppose that after one had been granted for one area to one set of undertakers, a rival would not be allowed to enter the area so Page 97. long as the first did their duty. (Memorandum of February 26th, Clause 6.)

The provisional orders, like the licenses, are subject to rules and regulations, and are revocable on failure to carry out the works. Pages 17, 20, 119, 144.

---

* Such provisional orders, when made, are mere reports for the assistance of Parliament, and hence, even if wrongly or illegally made, cannot be quashed by a Court of Justice.—*Frewen* v. *Hastings* (1865), 34 L. J. Q. B. 159. 6 B. & S. 401.

The supreme controlling and inspecting power is the Board of Trade, and the rights of the Postmaster General are reserved with respect to telegraphs, telegraphic apparatus and wires.

With the Electric Lighting Act, 1882, are incorporated the Page 15; 72.
agreement clauses of the Lands Clauses Act, the Gasworks Clauses Pages 49 & 60.
Acts, parts of the Public Health Act, 1875, the Local Loans Pages 72, 73.
Act, the Board of Trade Arbitrations Act, and parts of the Page 62.
Telegraph Acts. Page 65.

The local authorities will play an important part in electric lighting, either supplying the light themselves by manufacture or contract, or else regulating and controlling the conduct of those who do so.

As a general rule the local authorities entrusted under the Electric Lighting Act with the duty of superintending the interests of the public are the sanitary authorities of the district, to whom is committed the care of the public health. For a further account of these bodies see note to the schedule. Page 46

Before applying for a provisional order or license, the undertakers will of course consider the choice of an area, remembering that as the supply within the area is compulsory, they will do well to make it as compact as possible. In deciding whether to apply for a license, or an order, they will balance the short period of the one against the compulsory purchase clause in the other. In the case of local authorities it does not seem very material which is obtained, as the general powers in each case are very similar. There is less delay in getting a license, for it could be carried through in less than six months, whereas a provisional order must be notified before July, and will generally not be got in less than a year.

On the other hand the Board of Trade and the local authorities are concerned to see that the proposed undertakers are persons of means, who can carry out their scheme, and who can make or obtain the proper plant and machinery; that the conditions are fair to all parties, and the public duly protected. For this purpose the Board of Trade has been empowered to make rules as to the mode of applying for provisional orders and licenses, which Page 6.
are fully discussed in the section on procedure. In addition to this they may from time to time make regulations to provide Page 20.
for the public safety, and the local authorities may with a like object make bye-laws.

The form of the licenses and orders will in general depend on

Introduction.

the Board of Trade. A number of proposed draft licenses and provisional orders were sent in to them in 1882. These they have greatly modified, and out of them has proceeded the first provisional order issued by the Board of Trade, viz., that for Chelsea, and which, together with notes, is printed at page 98. Page 98.

Powers of the Undertakers.

SEC. 2.—*Provisional Orders and Licenses, and the Powers and Duties of the Undertakers.*

The powers and duties of the undertakers with regard to the supply of electricity, are much the same under a provisional order as under a license. Their powers and duties may be roughly summed up as follows: They may break up all public streets and places within their area, that are repairable by the local authorities (Gas Works Clauses Act 1847, sec. 6, Provisional Order, clause 12), on giving proper notice to the local authority and the Postmaster-General (Gas Works Clauses Act, 1847, secs. 8 and 9, Provisional Order, clause 13), and according to plans to be approved by them. They may also break up any streets over which the public have rights of way, although the same are not repairable by a local authority (Electric Lighting Act, sec. 13, Provisional Order, clause 14), on giving the like notice; and in addition on notifying the persons by whom the streets are repairable. They may also alter the position of wires and renew and replace them (Electric Lighting Act, sec 15, Gas Works Clauses Act, 1847, sec 7, Provisional Order, clause 15) on giving the notices therein provided. But they are to take care in doing so not to injuriously affect any existing telegraphic or telephonic lines (Provisional Order, clause 16). Moreover, the local authority if it sees fit, may exercise these powers for them (Electric Lighting Act, sec. 3, sub-sec. 9, and Provisional Order, clauses 17, 18), and make them pay the expenses thereof.

Page 49. Page 107. Page 54. Page 107. Pages 28, 50. Page 111. Page 115. Page 17. Page 116.

The undertakers are also bound to construct certain specified works within certain specified times, and others when required to do so by the local authority or private persons (Provisional Order, clause 19-29), and before they get their order or license they will have to provide and secure a certain specified capital (Provisional Order, clauses 8-10).

Page 118. Page 104.

In order to facilitate their acquisition of land, they have conferred upon them the benefit of the Lands Clauses Acts so far as the same enable lands to be taken by agreement from persons otherwise incapable of conveying them (Electric Lighting Act, sec. 12). But they have no compulsory purchasing powers.

Pages 24, 72.

Powers of the Undertakers.

As soon as they have commenced their work, they are to cause maps of their electric lines and works to be made and duly deposited for public inspection (Provisional Order, clauses 26-28), Page 122. and they are subjected to rigorous clauses as to the testing of electricity (Provisional Order, clauses 33-44) under inspectors appointed by the local authorities, Board of Trade, or by justices of the peace (Provisional Order, clauses 30-32).

The undertakers are bound to supply electricity for private purposes to all within the areas, as designated in their provisional order (Electric Lighting Act, sec. 19), without favour (Electric Lighting Act, sec. 20), though before doing so they may require Page 30. the consumers to undertake to use it (Provisional Order, clause 45-48), and the nature of the supply is accurately limited and defined (Provisional Order, clause 29). The maximum price is Page 123. also fixed at a rate about double that of gas of equivalent illuminating power (Provisional Order, clauses 49-52); but each provisional order will contain its own maximum price, which no doubt will vary in different districts.

A series of regulations is laid down with regard to meters (Provisional Order, clauses 53-63), whether purchased by the consumer or supplied or let on hire by the undertakers; and a series of provisions is made for public safety (Provisional Order, clause 64; and Electric Lighting Act, sec. 6). Of these the chief are that the conducting mains shall be of a pattern to be approved by the Board of Trade (as to size and insulation), and that the service wires shall be of sufficient dimensions. Limits are also placed on the electromotive forces, or pressures of the currents permitted to be used, and earth returns are prohibited for the present. The rights of the Crown (Provisional Order, clauses 76, 77) are saved, as also those of the Postmaster-General (Electric Lighting Act, secs. 26 and 35).

The undertakers have given to them special powers for the recovery of the rents due to them (Electric Lighting Act, sec. 21, and note thereto); and are also specially protected from theft, carelessness, and fraud (Electric Lighting Act, secs. 18, 22, 23), Page 29. and have powers of entry on premises for the purposes of their business (Electric Lighting Act, sec. 24).

And finally, if the undertakers neglect their business, or fail to Pages 17, 20, 119, 144. do their duty, or become bankrupt, then under sec. 6 (*f*) of the Electric Lighting Act, their powers may be revoked, and their wires removed (Provisional Order, clause 68).

Procedure for Provisional Orders.

Sec. 3.—*Procedure.*

The procedure necessary to be followed in applying for and obtaining provisional orders and licenses is laid down in the October Rules of the Board of Trade. The procedure is not the same in the two cases, and requires to be treated separately. Page 75.

Procedure in Provisional Orders.

Procedure in obtaining Provisional Orders.*

Page 75. To obtain a provisional order no previous consent of the local authority is necessary, though it has been decided (Rule II.) that local authorities, if they choose to apply, are in their own districts to be preferred to others.

Notice to Local Authority on or before July 1st.

If the applicant is not the local authority of the place to be lighted, then before July 1st notice must be given of the intended application for the provisional order to the local authority (Electric Lighting Act, 1882, sec. 4, sub-sec. 1, Rule VIII.) No special form is requisite, but a specimen form is printed among the forms (Provisional Order Forms, 1).† Pages 18 and 78. Page 153.

Passing of Resolution if Local Authority is Applicant.

If the local authority is the applicant, then, as in the case of a license, a resolution must be duly passed, as prescribed by sec. 3, sub-sec. 6, as applied to provisional orders by sec. 4; see also Rule VII. The month's notice convening the meeting must be in the usual form, and given in the manner usual for such meetings. A specimen of a notice of meeting in a borough is given (Form 2). Page 17. Page 77. Page 153.

The resolution when passed may be in some such form as Form 3. Page 154.

Insertion of Advertisements in October or November.

The next step is to insert in October or November the advertisements of the intended application, as provided by sec. 3, sub-sec. 5. Page 16.

Page 78. Rule IX. points out the exact method of drawing up and inserting these advertisements, and should be carefully followed. The exact form is not prescribed, but a specimen of a form of

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* The scale of costs of solicitors in obtaining provisional orders, is the chancery, and not the parliamentary scale.

† The forms printed at page 153 are not official forms issued by the Board of Trade, but only samples from among those which have been successfully used.

Procedure for Provisional Orders.

advertisement used by the Brush Company is printed among the forms to serve as a guide (Form 4). A large number of such forms will be found in the *Gazette* for November 21st, 1882, Page 154. page 5247 *et seq.*, and November 24th, 1882, page 5533 (Notice by a Local Authority).

Deposition of Copies of Advertisements and Maps on or before November 30th.

A copy of this advertisement, together with a published or the best procurable map with the boundaries of the proposed area marked upon it, must then be deposited at the office in England or Ireland of the Clerk of the Peace for the county, riding, or division, and of the local authority for every district, and in Scotland at the office of the principal sheriff clerk for every county, district, or division; and of the local authority of every district (Rule V.) This must be done on or before November 30th (Rule Page 76. XIV.), and on or before the same day copies of these documents Page 80. must also be deposited at the Board of Trade. (Rule XIV.)

The best mode of marking the area is by a wash of colour deepened at the edge so as to present a sharp outline. The electric wires or works need not be shown on the map. The scale must not be less than one inch to one mile. The ordnance survey maps serve this purpose very well (Rule V.) Page 76

Lodging of the Memorial and Accompanying Documents before December 21st.

The next step is to lodge the memorial at the Board of Trade Page 75. on or before December 21st (Rules III., V., VI.).

There is no special form for this memorial, but a specimen form is given (Form 5) and note Rule VI. (7). Pages 156 and 77.

With the memorial six copies of the draft of the proposed pro- See also visional order must be deposited. These are usually printed. "Proofs" Clause XII., Their form and contents will be discussed later on; but they will page 91 generally be in the form lately approved by the Board of Trade. Page 158. The Notice Form (11), prescribed by Rule IV., must be appended. Page 75.

A map of the district, coloured as before, must also be deposited (Rule V.), but as this will already have been done on or before Page 76. November 30th, it need not be done again.

There must also be deposited the following documents (Rule Page 77. VI.), which are usually drawn up on separate sheets of paper.

1. A list of the local authorities in whose districts the area of Page 157. supply is situate. (See Form 6.)

Procedure for Provisional Orders.

2. A list of the streets not repairable by a local authority, and of the railways, and tramways (if any), which the applicants propose to take powers to break up. (Form, 7 Electric Lighting Act, sec. 13.) Page 157.

3. A list of the canals and navigable rivers (if any) which the undertakers will be empowered to cross. (Form 8, Electric Lighting Act, sec. 16.) Page 157.

4. A statement of the capital proposed to be expended and employed in connexion with the undertaking and the mode in which such capital is to be provided (Form 9). Page 157. The capital will be obtained by a local authority under their borrowing powers; by a company or private firm from their shares. In the approved order, clauses 8, 9, and 10 are devoted to the regulations required as to capital. Page 104. In every case a separate sum is required to be "appropriated" by the undertakers to the purposes of the undertaking, and a heavy deposit or security is also required as caution money.

5. If the applicants are a company registered under the Companies Acts, a copy of the memorandum and articles of association must also be deposited.

6. A fee of 50*l.*, by cheque, payable to an "assistant secretary of the Board of Trade." This is intended to cover the ordinary expenses. Extra expenses will be charged on the applicants. At the offices of the Board of Trade, at Whitehall, a separate office is devoted to electric lighting matters.

Deposition of Copies of the Draft Provisional Order for Purchase by the Public at 1*s.*

Page 78. When the provisional order is applied for, Rules IV. and IX. a sufficient number of copies of it must be deposited at the offices in London and within the area, mentioned in the advertisements. These copies are to be sold at 1s. each to all persons applying for them.

Preparation and Lodging of the Proofs before February 25th.

The memorial and accompanying documents having been duly lodged, the next step is to prepare the proofs of due compliance with all the requirements of the Board of Trade. To facilitate this, forms of proofs are provided by the Board of Trade, and are sent to the applicants. A copy of such form for provisional orders is printed at page 88. The blanks are to be filled up

Procedure for Provisional Orders.

by the applicant with the title of the provisional order, and the names of the promoters, and the names of the various witnesses. This proof is so clear and full that it requires hardly any explanation.

Proof of Notice of Application to the Local Authority before July 1st.

It provides (III.) that an affidavit must be prepared of the due notice of the application to the local authority as provided in the Electric Lighting Act, sec. 4, sub-sec. 1, and Rule VIII. **Pages 18 and 78.**

Proof of the Due Passing of Resolution (if by Local Authority).

If the applicant is a local authority then due proof of the passing of the necessary resolution (Electric Lighting Act, sec. 3, sub-sec. 6, and Rule VII.) must be given, by the production of the certificate of the clerk to the local authority that the resolution was duly passed, the notice duly given, &c. A form of this certificate is given (Form 10). **Page 157.**

Proof of the Advertisements in October or November.

Copies of the gazettes and newspapers in which the advertisements of the application were inserted must be produced, and an affidavit must specifically set forth that the advertisement contained all those particulars which by Rule IX. it is required to **Page 90.** contain. (See clauses 5, 6.) And proof by affidavit must also be given that the whole notice was included in one advertisement (clause 7), that it was inserted once at least in each of two successive weeks in the proper newspaper (clause 8), and that such advertisements stated that objectors might apply to the Board of Trade by letter, &c. (See Rule IX., and **Page 78.** clause 9 of the "proofs.") **Page 90.**

Proof of the Deposition of Advertisements and Maps on or before November 30th.

It must also be shown by affidavit, or production of receipts for the same (clause 10), that the advertisements and maps were **Page 91** duly deposited with the clerk of the peace, the local authority, and the Board of Trade (clause 11). (See Rules V. and XIV.) **Page 76.**

Proof of Lodging of the Memorial and Accompanying Documents as Required by Rules III., IV., V., VI., and XIV., on or before December 21st. **Page 75.**

The details of this proof are set forth in clause 12, page 91.

Procedure for Provisional Orders.

No affidavit of this is necessary, as the facts will of course be within the knowledge of the Board of Trade officials, who will possess the necessary documents. The receipt which was given by the Board of Trade when the cheque of 50*l.* was paid will be required as proof of the payment.

Proof that the Proposed Draft Provisional Order is in Due Form.

This proof must be given by affidavit, and must allege specifically that the Draft Provisional Order contains all those things which Rule IV. requires that it should contain (see clause 13 of the Proofs). Page 75. Page 92.

Proof of the Supply of Copies for Sale to the Public at 1s. *each.*

This must be by affidavit, which must allege that at the offices in London, and also within the proposed area of supply, a sufficient number of copies of the Draft Provisional Order were deposited for sale at a price of not more than 1s. to all persons applying for them (clause 14 of the "Proofs"), Rule IV. Page 92.

Proof of Deposition at the Offices of the Board of Trade of a Description of any Lands Proposed to be Purchased for the Undertaking.

This is required by clause 15 of the "Proofs," and Rule XII.; and see sec. 10 of the Electric Lighting Act, 1882. The proof is to be by affidavit, and the agreements are to be produced for inspection. Pages 94 and 79.

There can be no difficulty in the drawing of the above-named affidavits, as they simply will follow the forms laid down in the official scheme of "proofs" issued by the Board of Trade. In general each separate proof will be a separate affidavit, for different people will have knowledge of the matters referred to. Instead of affidavits statutory declarations are allowed if duly stamped.

The proofs, as has been said, must be ready before January 25th. The Board of Trade will fix a day (and notify it to the applicants six days beforehand) on which to attend and give in the proofs. The proofs must be complete before February 25th. Page 80.

Objections to the Proposed Provisional Order.

These must be lodged within two months of the date of the first advertisement in the newspapers (Rules XI. and IX., clause 8). If any objector desire a local inquiry he should ask Page 78.

Procedure for Provisional Orders.

for it. If he be an interested person it will be granted as of course, proper security being taken for the costs if thought necessary. If he have no locus to demand an inquiry, the Board of Trade will use its discretion. As to local inquiries, see also Electric Lighting Act, sec. 3, sub-sec. 5, and sec. 5; Rules X., XI., and Board of Trade Arbitrations Act, 37 and 38 Vict. c. 40, secs. 2 and 3. Pages 79 and 62.

No particular form is necessary for these objections.

After the proofs above-mentioned have been satisfactorily given, and after the interested persons have had an opportunity of having their objections heard (Electric Lighting Act, 1882, sec. 3, sub-sec. 5), the Board of Trade may grant a provisional order, copies of which are, as before, to be deposited for inspection as provided by Rule V., and for sale to the public, (Rule IV., Rule XIII.) Page 16.

The Provisional Order is, however, of no force until confirmed by Bill in Parliament (Electric Lighting Act, 1882, sec. 4, sub-sec. 2). Against this Bill petitions may be presented in the usual way (sec. 4, sub-sec. 3), and the same, even when passed, may subsequently, on the application of the undertakers, be repealed, altered, or amended by any subsequent provisional order. The Board of Trade and the public have no further control over a provisional order when once confirmed, which becomes like a special Act of Parliament. To meet this, it will be found that in the provisional order lately issued by the Board of Trade, provision is made in several cases for the alteration of the powers and duties of the undertakers. Page 18.

The procedure in taking a provisional order through Parliament depends on whether it is or is not opposed, and varies from time to time according to the standing orders. A brief sketch of it is given in May's "Parliamentary Practice." See 34 and 35 Vict. c. 3; 34 and 35 Vict. c. 83.

PROCEDURE IN OBTAINING LICENSES.

Procedure Licenses.

As is pointed out elsewhere, there is no great difference between a license and a provisional order, but the mode of obtaining them is somewhat different. In the case of provisional orders, as they require to be confirmed by Parliament, certain fixed times are specified, so that the preliminaries may be completed before the session begins; but in the case of licenses these special times are not prescribed. Page 4.

In applying for a license, the first thing is to get it "entertained" by the Board of Trade. To procure this, the following steps must be taken.

Procedure Licenses.

Obtaining of the Consent of every Local Authority within the proposed area.

This consent, which is requisite under sec. 3, (1), of the Electric Lighting Act, and Rules I. and VII., must be obtained by a regularly passed resolution, at a special meeting after a month's notice, duly published. Page 16.

When the Local Authority is the Applicant

Page 77. Consent is of course not required, unless the local authority proposes to light any part of an area outside its own district; but a resolution to apply for the license must be duly passed, as provided in Rule VII.

Application by Memorial for the License.

This having been done, the applicants must next apply by memorial for the license.

The memorial must have a proper title, as provided in Rule III., and request consent for the breaking up of streets indicated in Rule VI. (7). Page 77.

With the memorial must be deposited the documents specified in Rules III., VI., and V. These documents are specified in clause 6 of the "proofs" for licenses, and are the same with those deposited with a memorial praying for a provisional order. A map on a scale of not less than one inch to a mile must also be deposited (Rule V.) For the forms of these, the forms used for Provisional Orders, Nos. 5—9, may be adapted. Page 83. *Ante*, page 7. Page 156

Deposition of Copies of the Draft License, for Purchase by the Public at 1s.

Ante, page 8. This must be done (Rules IV. and IX. (8) just as in the case of provisional orders, when the memorial is lodged.

Deposition of Map of the proposed Area with the Clerk of the Peace and Local Authority.

Page 78. This must be done when the memorial is lodged (see Rules V. and IX. [8]). It is the same as in the case of a provisional order; but that, as no advertisement has as yet been made, none can be deposited.

Entertainment of the Application for a License.

This, as soon as resolved on, will be communicated to the applicant by the Board of Trade. As soon as the application is entertained,

Procedure Licenses.

the next step will be to give notice of it to the public, in order that objections may be heard to its being finally granted.

Advertisement of Application to be inserted after it is entertained.

This will be almost exactly in the form of the advertisement for a provisional order, and must contain the essential points laid down in Rule IX., and formulated again in clause 11 of the "Proofs" for licenses. Page 86.

Objections must be lodged within two months of the date of the first advertisement (Rules IX., XI.): they need not be in any particular form. Page 78. As soon as they have been heard, and any other necessary inquiries disposed of (Electric Lighting Act, sec. 3, sub-sec. 5, sec. 5; Rules X., XI.; Board of Trade Arbitrations Act, 37 & 38 Vict., cap. 40, secs. 2 and 3), Page 79. and after the lapse of three months from the date of the first advertisement (Electric Lighting Act, sec. 3, sub-sec. 5), the license may be granted.

But before it is so granted, the full proofs required by the Board of Trade, and formulated in the document A., Proofs for Licenses, must be complied with. Page 81. These proofs are very similar to those in the case of provisional orders, to which the reader is referred. Page 9. They are as follow:

Proof of the Consent of all the Local Authorities.

By affidavit, with a list of local authorities as an exhibit, and by production of the certificate of the clerks of local authorities that the resolution was duly notified and duly passed at a special meeting (see clauses 3 and 4 Licenses "Proofs." Page 81.

When the Applicants are the Local Authority.

By production of the certificate of resolution to apply for a license. This, *mutatis mutandis*, will be the same as in the case of a resolution to apply for a provisional order. See p. 6. See Clause V page 82.

Proof of Due Lodging of the Memorial and Necessary Documents of the Board of Trade.

This may be made personally or by affidavit. The details are set out in clause 6. Page 83.

Proof that the Draft License is in the proper form, as required by Rule IV.

This must be given by affidavit and must allege specifically that the Draft License contains all those things that it should contain by Rule IV. (see clause 7 of Proof.) Page 84.

Procedure Licenses.

Proof of the Supply of Copies for Sale to the Public at 1s. each.

This must be by affidavit, which must be exactly similar to that in the case of provisional orders, see ante p. 10. Rule IV. and clause 8 of Proofs for Licenses. Page 85.

Proof of Deposition of the Map at the Offices of the Clerk of the Peace, or Sheriff Clerk.

This must be by affidavit or by the production of receipts. Proofs, clause 9 and Rule V. Page 85.

These will complete the proof that the requirements preliminary to the entertainment of the application for the License, were duly fulfilled.

It will next be necessary to show that the requirements after the application was entertained, were also carried out. This is done by

Proof of due Publication of Proper Advertisements.

By producing copies of them, and a specific affidavit that they contain all those things required by Rule IX. (see clauses 10, 11. of Proofs for Licenses.) Pages 78, 86.

Proof by affidavit must also be given that the whole notice was included in one advertisement (clause 12), that it was inserted once at least, in each of two successive weeks, in the proper newspapers (clause 13), and that such advertisements stated that objectors might apply to the Board of Trade by letter, etc. (see Rule IX. and clause 14 of the Proofs for Licenses). Page 87.

Proof of Depositions of Descriptions of Lands proposed to be purchased.

Page 87. This must be given by affidavit (sec. 10 E. L. Act, 1882. Rule XII. and clause 15 of Proofs for Licenses); and the agreement must be produced for inspection.

The forms for applications for licenses will so closely resemble those for provisional orders, that I have not repeated them. The Board of Trade have not issued any stereotyped forms; but the rules must be carefully observed.

As soon as the above proofs are correct, and the three months have elapsed, the license may be granted, and comes into force at once. The license lasts for the period named in it, not exceeding seven years, but it may be renewed from time to time. No special form of application for renewals has been laid down, but it would probably be just the same as in the original application.

THE

ELECTRIC LIGHTING ACT, 1882.

45 & 46 VICT. cap. 56.

AN ACT

TO

FACILITATE AND REGULATE THE SUPPLY OF ELECTRICITY FOR LIGHTING AND OTHER PURPOSES IN GREAT BRITAIN AND IRELAND.

[18*th August*, 1882.

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:— A.D. 1882.

Short Title. 1. This Act may be cited for all purposes as the Electric Lighting Act, 1882.

Application of Act. 2. The provisions of this Act shall apply to every local authority,(*a*) company,(*b*) or person who may by this Act or any license or provisional order granted under this Act, or by any special Act to be hereafter passed, be authorised to supply electricity(*b*) within any area(*c*) (in this Act referred to as "the undertakers") and to every undertaking so authorised, except so far as may be expressly provided by any such special Act; and every such license, provisional order, and special Act, is in this Act included in the expression "license, order, or special Act."

(*a*) Defined secs. 31, 36, and schedule.

(*b*) Defined sec. 32.

Sec. 2.

(*c*) This area may be any portion of land marked out by the special Act, order, or license. It need not be conterminous with any existing boundaries or divisions. There would, of course, be a tendency to make it co-extensive with the parishes or other sanitary divisions.

The persons who may be authorised are either the local authorities as defined in the schedule, or private companies or firms. Preference will be given to the local authorities within their own districts in cases of Provisional Orders. Rule II. No license can be granted without their consent. (Sec. 3, subsec. 1.) Page 75.

Sec. 3. **Granting of licenses authorising the supply of electricity.**

3. The Board of Trade may from time to time license any local authority as defined by this Act, or any company or person, to supply electricity under this Act for any public or private purposes within any area, subject to the following provisions:

(1.) The consent of every local authority having jurisdiction within the area or any part of the area within which a supply is licensed to be furnished shall be required to the application for a license, which consent such local authority is hereby authorised to give, with such conditions (if any) as, subject to the approval of the Board of Trade, the local authority may prescribe:

(2.) A license shall be for any period not exceeding seven years, but may, at or after the expiration of such license, be renewed from time to time for a like period with such consent as above-mentioned upon such terms and conditions as the Board of Trade may determine:

(3.) "Public purposes" shall mean lighting any street or any place belonging to or subject to the control of the local authority, or any church or registered place of public worship, or any hall or building belonging to or subject to the control of any public authority, or any public theatre, but shall not include any other purpose to which electricity may be applied:

(4.) "Private purposes" shall include any purposes whatever to which electricity may for the time being be applicable, not being public purposes, except the transmission of any telegram:

Rule IX. Page 78.

(5.) Every local authority, company, or person applying for a license shall publish notice of their application by public advertisement in such manner and including such particulars as the Board of Trade may from time to time direct or approve; and such license shall not be granted by the Board of Trade until after the expiration of a period of three months from the date of the first publica-

Sec. 3.

tion of such advertisement, nor until opportunity has been given to all parties interested to make representations or objections to the Board of Trade with reference to the application: Page 1.

(6.) No application for a license shall be made by any local authority except in pursuance of a resolution to be passed at a special meeting of the local authority, and such special meeting shall only be held after one month's previous notice of the same and of the purpose thereof has been given in the manner in which notices of meetings of such local authority are usually given: Rule VII. Page 12.

(7.) A license may, subject to the provisions of this Act, be granted to a local authority authorising them to supply electricity within any area although the same or some part thereof may not be included within their own district:

(8.) The license may make such regulations as to the limits within which and the conditions under which a supply of electricity is to be compulsory or permissive, and for enforcing the performance by the licensees of their duties in relation to such supply, and for the revocation of the license where the licensees fail to perform such duties, and generally may contain such regulations and conditions as the Board of Trade may think expedient: See sec. 6.

(9.) Where in any area or part of an area in which any undertakers are authorised to supply electricity under any license the undertakers are not themselves the local authority, the license may contain any provisions and restrictions for enabling the local authority within whose jurisdiction such area or part of an area may be to exercise any of the powers of the undertakers under this Act with respect to the breaking up of any street repairable by such local authority within such area or part of an area, and the alteration of the position of any pipes or wires being under such street, and not being the pipes or wires of the undertakers, on behalf and at the expense of the undertakers, and for limiting the powers and liabilities of the undertakers in relation thereto, which the Board of Trade may think expedient.

For the definitions of local authorities, companies, electricity, see secs. 31, 32, 36, and schedule. This section deals with licenses, which have already been described in the introduction. They may be granted by the Board of Trade with the consent of the local authority. They last seven years, but are

Secs. 3, 4.

renewable. While they last they have much the effect of a private Act of Parliament. The only superiority of an order is, that being confirmed by Parliament, no question can arise as to the validity of its provisions, while in granting a license the Board of Trade must keep strictly within their statutory powers.

(3.) "Street" is defined in sec. 32. See also note to the Gasworks Clauses Act, 1847, secs. 6 and 7.

Page 49.

The only "public purposes" are the lighting of streets and public places. Private lighting supply, or supply for any other purposes whatever, is called a supply for private purposes.

Note the different meaning of the words "public purposes" in the application of the Act to Scotland; and see Rule IV. (3), which requires that draft licenses or orders shall contain a statement of the purposes for which the supply is required.

(9.) See also sec. 14. For a specimen of such restrictions see the Provisiona Order, clauses 17, 18.

Granting of provisional orders authorising the supply of electricity.

4. The Board of Trade may, from time to time, by provisional order, authorise any local authority, company, or person to supply electricity for any public or private purposes within any area, without requiring such consents as are required to the granting a license under this Act, and for such period, whether limited or unlimited, as the Board of Trade may think proper, but in all other respects subject to the like provisions as in the last section contained with respect to licenses, and subject also to the following provisions:—

(1.) No provisional order shall authorise the supply of electricity by any undertakers within the district of any local authority (not being themselves the undertakers), unless notice that such provisional order has been or is intended to be applied for has been given to such local authority by the applicants in such manner as the Board of Trade may direct or approve on or before the first day of July in the year in which such application is made; provided that in the case of any application made during the present year such notice shall be deemed to have been given in due time if the same is given within one month after the passing of this Act:

(2.) The Board of Trade may submit to Parliament for confirmation any provisional order granted by it in pursuance of this Act, but any such order shall be of no force unless and until it is confirmed by Act of Parliament:

(3.) If, while the Bill confirming any such order is pending in either House of Parliament, a petition is presented against any order comprised therein, the Bill, so far as it relates to such order, may be referred to a Select Committee, and the petitioner shall be allowed to appear and oppose as in the case of private Bill:

(4.) Any Act confirming any provisional order granted in pursuance of this Act may, on the application of the undertakers thereby authorised to supply electricity, be repealed, altered, or amended by any subsequent provisional order granted by the Board of Trade and confirmed by Parliament.

All the provisions of sec. 3, except (1) and (2), apply to provisional orders, by the provisions of the opening paragraph of sec. 4.

The nature of a provisional order is pointed out in the introduction (p. 2). It is granted by the Board of Trade without the consent of the local authority, but after notice to them, and when granted is confirmed by Parliament; after which it takes effect. It is equivalent to a special Act of Parliament.

The machinery of provisional orders is not a new thing. It has long been in force for tramways, gasworks, and other matters. An order, when once confirmed, cannot be altered by another provisional order, except on the undertakers' application. To alter an order against the wish of the undertakers would require a special Act.

Making of rules as to the application, &c., under Act.

5. The Board of Trade may from time to time make, and when made may rescind, alter, or repeal rules in relation to the applications for licenses or provisional orders, and to the payments to be made in respect thereof, and to the publication of notices and advertisements, and the manner in which and the time within which representations or objections with reference to any application are to be made, and to the holding of local inquiries in such cases as they may think it advisable, and to any other matters arising under this Act.

Any rules made in pursuance of this section shall be deemed to be within the powers conferred by this Act, and shall be of the same force as if enacted in this Act, and shall be judicially noticed.

Any rules made in pursuance of this section shall be laid before Parliament within three weeks after they are made if Parliament be then sitting, and if Parliament be not then sitting, within three weeks after the beginning of the next session of Parliament.

Under these powers, the Board of Trade made a set of rules regarding the procedure in applying for provisional orders and licenses. These were finally settled in October, 1882. Page 75.

They must not be confounded with "Regulations for Public Safety" which may be made from time to time under sec. 6 or with the Byelaws for Public Safety, which may be made by the local authorities.

Local inquiries will always be made if demanded by any interested person having a locus to demand them on proper terms as to costs (see Rule X. and Board of Trade Arbitration Acts, secs. 2, 3). Pages 79 and 62.

Regulations to be inserted in licenses, &c.

6. The undertakers shall be subject to such regulations and conditions as may be inserted in any license, order, or special Act, affecting their undertaking with regard to the following matters:

(*a*) The limits within which and the conditions under which a supply of electricity is to be compulsory or permissive;
(*b*) The securing a regular and efficient supply of electricity;
(*c*) The securing the safety of the public from personal injury, or from fire or otherwise;
(*d*) The limitation of the prices to be charged in respect of the supply of electricity;
(*e*) The authorising inspection and inquiry from time to time by the Board of Trade and the local authority;
(*f*) The enforcement of the due performance of the duties of the undertakers in relation to the supply of electricity by the imposition of penalties or otherwise, and the revocation of the license, order, or special Act where the undertakers have, in the opinion of the Board of Trade, practically failed to carry the powers granted to them into effect within a reasonable time, or discontinued the exercise of such powers; and
(*g*) Generally with regard to any other matters in connexion with the undertakings.

Provided always, that the Board of Trade may, from time to time, make such regulations as they may think expedient for securing the safety of the public from personal injury or from fire or otherwise, and may from time to time amend or repeal any regulations which may be contained in any such license, order, or special Act, in relation thereto; and any regulations so made or amended by the Board of Trade shall, from and after the date thereof, have the like effect in every respect as though they had been originally inserted in the license, order, or special Act authorising the undertaking, and every regulation so repealed shall, from and after the date thereof, be repealed accordingly, but such repeal shall not affect any liability or penalty incurred in respect thereof prior to the date of such repeal or any proceeding or remedy which might have been had in relation thereto.

Any local authority within any part of whose district electricity is authorised to be supplied under any license, order or special Act may, in addition to any regulations which may be made under the preceding provisions of this section for securing the safety of the public, from time to time make, rescind, alter, or repeal byelaws for further securing such safety; and there may be annexed to any breach of such byelaws such penalties to be recovered in a summary manner as they may think necessary: Provided always, that no such byelaws shall have any force or effect unless and until they have been confirmed by the Board of Trade and published in such manner as the Board of Trade may direct.

(*a*, *b*, *f*) This seems little more than a repetition of sec 3, sub-sec. 8. The conditions must appear on the face of the order, Rule IV., and see the various clauses in the Chelsea Provisional Order. Page 98.

(*c*) See the Chelsea Provisional Order, Clause 64.

(*d*) See the Chelsea Provisional Order, Clauses 49-52.

(*e*) See the Chelsea Provisional Order, Clauses 30-44.

(*f*) See the Chelsea Provisional Order, Clauses 67-68.

The Board of Trade safety regulations are distinct from the approved byelaws of the local authority. It is needless to say that these safety regulations and byelaws must be reasonable, and within the powers of the makers, otherwise they could not be considered binding in the Courts of Law.

None have as yet been made save those incorporated in the Provisional Orders.

Expenses of local authority.

7. Any expenses incurred by a local authority under this Act, and not otherwise provided for, including any expenses incurred in connexion with the obtaining by them, or any opposition to the obtaining by any other local authority, company, or person, of any license, order, or special Act under this Act, may be defrayed out of the local rate as defined in the schedule to this Act, and the local authority may from time to time cause such rates to be levied as may be necessary for the purpose of defraying such expenses; provided that where such local authority is a rural sanitary authority such expenses shall be deemed to be special expenses within the meaning of the Public Health Act, 1875.

The powers of the local authorities to raise the money necessary for electric lighting are laid down in the schedule. The object of the Act has been to

38 & 39 Vict. c. 55.

give them the same powers as regards electric lighting as they have had with regard to gas lighting and other sanitary matters. The powers of the local authorities to borrow money and charge it on the rates are contained chiefly in the Public Health Act, 1875, and in the Local Loans Act 1875.

Pages 72 and 74.

The object of the Act is, that the expense of electric lighting shall be located as much as possible. Thus rural authorities are directed to levy it out of special rates, falling on the various "contributory places," that is in general on the parishes. (See the schedule.)

Power of local authority to borrow mo- money.

8. A local authority authorised to supply electricity by any license, order, or special Act may from time to time borrow money on such security, with such consent and subject to such provisions and restrictions with respect to borrowing and the repayment of loans, as are in the schedule to this Act in that behalf mentioned, and the money so borrowed shall be deemed to be borrowed under the enactments subject to the provisions and restrictions of which it is borrowed, and the accounts of all receipts and expenditure by the local authority in pursuance of this Act, or any license, order, or special Act, shall be subject to such audit as is in the said schedule in that behalf mentioned: Provided always, that any moneys borrowed under this section by the local authority of any district to which the Local Loans Act, 1875, extends, may if it is thought fit, be borrowed in manner provided by that Act; and in the construction of the said Act for the purposes of this Act the expression "prescribed" means prescribed by any conditions imposed by the authority whose consent is required to borrowing under this section.

38 & 39 Vict. c. 83.

Where any local authority is authorised by any Act to raise any money which they may be empowered to borrow for certain purposes by the issue of corporation or other stock, any money which a local authority may be authorised to borrow under this section may, if it is thought fit, be raised by them by the issue of such stock as aforesaid.

This section shall not apply to the mayor, commonalty, and citizens of the City of London, or to the Metropolitan Board of Works, except in so far as the Metropolitan Board of Works may be concerned in the borrowing of any money by any vestry or district board.

I have not dealt with the borrowing powers of local authorities, because this seemed rather to belong to works on local government, such as those of Lumley and Glen.

The statutes regulating it are, The Public Health Act, 1875 (38 & 39 Vict.

Secs. 8, 9, 10, 11.

c. 45, secs. 233-244), see also the Local Loans Act (38 & 39 Vict. c. 83), and the Public Works Loans Act, 1875 (38 and 39 Vict. c. 89). See the schedule.

Accounts.

9. The undertakers shall on or before the twenty-fifth day of March in every year, fill up an annual statement of accounts of the undertaking, made up to the 31st day of December then next preceding; and such statement shall be in such form and shall contain such particulars and shall be published in such manner as may from time to time be prescribed in that behalf by the Board of Trade.

The undertakers shall keep copies of such annual statement at their office, and sell the same to any applicant at a price not exceeding one shilling a copy.

In case the undertakers make default in complying with the provisions of this section, they shall be liable to a penalty not exceeding forty shillings for each day during which such default continues.

No rules as to accounts have as yet been issued. The accounts of gas undertakings are dealt with in the Gasworks Clauses Act, 1871 (34 & 35 Vict., cap. 41, sec. 35). Page 60.

General powers of undertakers under license or provisional order.

10. The undertakers may, subject to and in accordance with the provisions and restrictions of this Act, and of any rules made by the Board of Trade in pursuance of this Act, and of any license, order, or special Act authorising or affecting their undertaking, and for the purpose of supplying electricity, acquire such lands by agreement, construct such works, acquire such licenses for the use of any patented or protected processes, inventions, machinery, apparatus, methods, materials, or other things, enter into such contracts, and generally do all such acts and things as may be necessary and incidental to such supply.

See Chelsea Provisional Order, clause 12. This section is chiefly needed where the undertakers are a local authority; for companies would in general be empowered and governed by their memorandum and articles of association,—whereas, to enable the local authorities to construct electric works and pay for them, some special authorisation would be necessary. As to the powers of undertakers to purchase lands by agreement from persons otherwise incapable of selling, see sec. 12 (1), which incorporates the agreement clauses of the Lands Clauses Acts. Page 107.

11. Any local authority who have obtained a license, order, or special Act for the supply of electricity, may contract with any company or person for the execution and maintenance of any

Secs. 11, 12.

Power for local authority to contract in certain cases and restrictions on assignments of powers, &c. of undertakers.

works needed for the purposes of such supply, or for the supply of electricity within any area mentioned in such license, order, or special Act, or in any part of such area; but no local authority company, or person shall by any contract or assignment transfer to any other company or person or divest themselves of any legal powers given to them, or any legal liabilities imposed on them by this Act, or by any license, order, or special Act, without the consent of the Board of Trade.

This section is also necessary to confer powers on local authorities, and probably indicates a good method of procedure. For while it affords to the consumer the guarantee of an undertaker of means sufficient to supply him with electricity, it enables private firms to contract with the local authority without being under the necessity of having their works compulsorily bought up, or being obliged to enter into any conditions more onerous than those which they choose to adopt. This section would probably be of use where a local authority is already the owner of gasworks, for the same machinery of inspection and collection could probably be utilized both for gas and electricity, the works placed in the same yards, and the wires put alongside of the gas pipes, which (with the leave of the Board of Trade) could even be used for return mains. Chelsea Provisional Order, clauses 11 and 64 (c).

Page 106.

Incorporation of certain provisions of Clauses Consolidation Acts.

12. The provisions of the following Acts shall be incorporated with this Act; that is to say,

(1.) The Lands Clauses Acts, except the enactments with respect to the purchase and taking of lands otherwise than by agreement, and except the enactments with respect to the entry upon lands by the promoters of the undertaking; and

10 & 11 Vict. c. 15.

(2.) The provisions of the Gasworks Clauses Act, 1847, with respect to breaking up streets for the purpose of laying pipes, and with respect to waste or misuse of the gas, or injury to the pipes and other works, except so much thereof as relates to the use of any burner other than such as has been provided or approved of by the undertakers; and

34 & 35 Vict. c. 41.

(3.) Sections thirty-eight to forty-two inclusive, and sections forty-five and forty-six, of the Gasworks Clauses Act, 1871.

For the purposes of this Act, in the construction of all the enactments incorporated by this section "the special Act" means this Act inclusive of any license, order, or special Act; and the "promoters" or "undertakers," and "the undertaking," as the case may be, mean the undertakers and the undertaking respectively under this Act.

In the construction of the said Lands Clauses Acts, "land" includes easements in or relating to lands.

In the construction of the said Gasworks Clauses Act, 1847, and the Gasworks Clauses Act, 1871, the said Acts shall be construed as if "gas" meant "electricity," and as if "pipe" meant electric line, and "works" meant "works" as defined by this Act, and as if "the limits of the special Act" meant the area within which the undertakers are authorised to supply electricity under any license, order, or special Act.

All offences, forfeitures, penalties, and damages under the said incorporated provisions of the said Acts or any of them, may be prosecuted and may be recovered in manner by the said Acts respectively enacted in relation thereto, provided that sums recoverable under the provisions of section forty of the Gasworks Clauses Act, 1871, shall not be recovered as penalties, but may be recovered summarily as civil debts.

(1.) These Lands Clauses Acts are by secs. thirty-two and thirty-six defined as follows:— Page 72.

(a.) Lands Clauses Act, 1845 (England and Ireland) 8 and 9 Vict., c. 18. The whole Act, with the exception of secs. 16-68 inclusive. The words in the above sub-section incorporating the Lands Clauses Acts, "except the enactments as to taking lands otherwise than by agreement," have received a judicial interpretation : *Reg.* v. *Lord Mayor of London* (1867), L. R. 2 Q. B. 292 ; *Ferrar* v. *Commissioners of Sewers* (1869) L. R. 4 Ex. 227.

(b.) The Lands Clauses Act, 1845 (Scotland), 8 and 9 Vict., c. 19. This Act is almost identical with the Act of the same year for England and Ireland.

(c) The Lands Clauses Act, 1860 (England, Ireland, and Scotland), 23 and 24 Vict., c. 106.

(d.) The Lands Clauses Act, 1869 (England and Ireland), 32 and 33 Vict., c. 18.

The effect of the Lands Clauses Acts, 1845 (*a*, *b*), is to enable the promoters to purchase lands by agreement from parties under a disability to sell, who are also enabled to enfranchise copyholds and grant releases. The purchase-money to be ascertained by valuation, and paid into the bank. Power is also given to promoters to re-sell the lands so acquired, and Municipal Corporations are not to sell without the consent of the Treasury. The Act of 1860 so far modified this as to enable the purchase-money to be paid by way of rent-charges instead of a gross sum. The Act of 1869 provided for the settlement of disputed compensation by arbitration.

The decided cases on these Acts are so numerous as to be impossible to treat in a work like the present. The reader is, therefore, referred to the special works on the subject.

(2.) The provisions here incorporated are those of the Gasworks Clauses Act, 1847 (England), 10 and 11 Vict. c. 15, secs. 6-20 and 40 (inclusive). They are printed at p. 49. The general nature of these provisions is as follows: They enable the undertakers, after giving notice to the people having control of the streets, &c. (sec. 8), and under their superintendence (sec. 9), to break up streets, sewers, tunnels, &c. (sec. 6) duly reinstating the same without delay (secs. 10, 11, 12), provided, however, that they may not enter on private land without the consent of the owners and occupiers, except to make renewals or repairs (sec. 7). They may contract for the lighting by, or supply of, gas (electricity) wires, meters and lamps for private, public, and street lighting (sec. 13), and for the hiring out of meters which are not to be subject to distress (sec. 14). They may enter buildings to inspect meters (sec. 15), and cut off the gas (electricity) in default of payment of rent due, which rent, together with the expenses of cutting off, they may recover in a summary manner. (Secs. 16, 17, 40.) (Sec. 18) provides against the fraudulent use of gas (electricity), or its supply by the consumer to any other persons under penalties, and (sec. 19) deals with the wilful injury to the undertakers' works. (Sec. 20) deals with carelessness or accidental damage to the works of the undertakers, and (sec. 40) points out the mode of recovering damages or penalties.

(3.) The Gasworks Clauses Act, 1871 (34 and 35 Vict. c. 41, secs. 38-42, (inclusive), 45, 46):

(Sec. 38) amends (sec. 18) of the Gasworks Clauses Act, 1847 (10 Vict. c. 15) by providing more stringently against tampering with meters, or fraudulently abstracting gas. (For further provisions against stealing electricity, see Electric Lighting Act, 1882, secs. 22, 23.) (Sec. 39) of the Gasworks Clauses Act, 1871, amends sec. 16 of the Gasworks Clauses Act, 1847, (10 Vict., c. 15) by providing that (except in the case of certain agreements) incoming tenants cannot be compelled to satisfy arrears of rent left by outgoers. (Sec. 40) of the Gasworks Clauses Act, 1871 (as amended by the Electric Lighting Act, 1882, sec. 12, last paragraph), enables rents for electricity to be recovered summarily as civil debts, but without taking away the ordinary civil rights of action of the undertakers (sec. 41), and (sec. 42) permits summonses or warrants issued for the purposes of the Act to contain more than one name. (Sec. 45) provides the modes in which notices are to be served, and (sec. 46) enables Justices and County Court Judges to act, notwithstanding they may be liable to gas rents or other charges under the Act. (The Act is printed at p. 60.)

Some further remarks on the various sections will be found appended to the sections themselves, to which the reader is referred to avoid repetition.

Restriction on breaking up of private streets, railways, and tramways.

13. Nothing in this Act or in any Act incorporated therewith shall authorise or empower the undertakers to break up any street which is not repairable by such local authority, or any railway or tramway, without the consent of the authority, company or person by whom such street, railway, or tramway is repairable, unless in pursuance of special powers in that behalf inserted in the license, order, or special Act, or with the written consent of the Board of Trade, and the Board of Trade shall not in any case insert any such special powers in any license or provisional order, or give any such consent until notice has been given to such authority, company, or person, by advertisement or otherwise, as the Board of Trade may direct, and an opportunity has been given to such authority, company, or person to state any objections they may have thereto.

See p. 47.

It seems that under the provisions of the Gasworks Clauses Act, 1847, the undertakers have no power to interfere with private streets over which the public have no rights of way. They can only break up public streets, railways, and tramways on giving notice to the parties by whom those streets are repairable. See secs. 6 and 7 of the Gasworks Clauses Act, 1847. As to the notices to be given, see Rules VI. and VIII., and see sec. 14 of the Chelsea Provisional Order.

Page 109.

Restrictions as to above-ground works.

14. Notwithstanding anything in this Act or in any Act incorporated therewith, the undertakers shall not be authorised to place any electric light above ground, along, over, or across any street, without the express consent of the local authority, and the local authority may require the undertakers to forthwith remove any electric line placed by them contrary to the provisions of this section, or may themselves remove the same, and recover the expenses of such removal from the undertakers in a summary manner; and where any electric line has been placed above ground by the undertakers in any position, a court of summary jurisdiction, upon complaint made, if they are of opinion that such electric line is or is likely to become dangerous to the public safety, may, notwithstanding any such consent as aforesaid, make an order directing and authorising the removal of such electric line by such person and upon such terms as they may think fit.

Electric overhead mains or wires of enormous dimensions would be unsightly and dangerous, and hamper fire-escapes. But there seems no reason why they might not (by agreement) be placed along the parapets of rows of houses, to which they could be fixed by brackets, provided they went round the blocks of houses, and did not cross the streets.

Power to undertakers to alter position of pipes and wires.

15. Subject to the provisions of this Act and of the license, order, or special Act authorising them to supply electricity, and to any byelaws made under this Act, the undertakers may alter the position of any pipes or wires being under any street or place authorised to be broken up by them which may interfere with the exercise of their powers under this Act, on previously making or securing such compensation to the owners of such pipes or wires, and on complying with such conditions as to the mode of making such alterations as may before the commencement of such alterations be agreed upon between the undertakers and owners, or in case of difference as may be determined in manner prescribed by the license or provisional order authorising the undertakers to supply electricity, or where no such manner is prescribed as may be determined by arbitration, and any local or other public authority, company, or person may in like manner alter the position of any electric lines or works of the undertakers, being under any such street or place as aforesaid, which may interfere with the lawful exercise of any powers vested in such local or other public authority, company, or person in relation to such street or place, subject to the like provisions, conditions, and restrictions as are in this section contained with reference to the alteration of the position of any pipes or wires by the undertakers.

Sec. 28.

Page 50.

This section extends sec. 7 of the Gasworks Clauses Act, 1847, at the same time that it confers reciprocal powers on other public authorities and persons, to alter the wires of the undertakers. In general the tendency would be as far as possible to let each person execute his own works.

Clauses for protection of canals.

16. If at any time after the undertakers have placed any works under, in, upon, over, along or across any canal, any person having power to construct docks, basins or other works upon any land adjoining to or near such canal, constructs any dock, basin or work on such land, but is prevented by the works of the undertakers from forming a communication for the convenient passage of vessels with or without masts between such dock, basin or other work, and such canal; or if the business of such dock, basin or other work is interfered with by reason or in consequence of any such works of the undertakers, then the undertakers at the request of such person, and on having reasonable facilities afforded them by him for placing works round such dock, basin or other work, under, in, upon, over, along or across land belonging to or under his control, shall remove and place their work accordingly.

If any dispute arises between the undertakers and such person as to the facilities to be afforded to the undertakers, or as to the direction in which the works are to be placed, it shall be determined by arbitration. Sec. 28

Compensation for damage.

17. In the exercise of the powers in relation to the execution of works given them under this Act, or any license, order, or special Act, the undertakers shall cause as little detriment and inconvenience and do as little damage as may be, and shall make full compensation to all bodies and persons interested for all damage sustained by them by reason or in consequence of the exercise of such powers, the amount and application of such compensation in case of difference to be determined by arbitration.

This clause amplifies the concluding paragraph of sec. 6 of the Gasworks Clauses Act, 1847, 10 Vict. c. 15. (See the note to secs. 6 & 7 of the same.) Page 49.

Undertakers not to prescribe special form of lamp or burner.

18. The undertakers shall not be entitled to prescribe any special form of lamp or burner to be used by any company or person, or in any way to control or interfere with the manner in which electricity supplied by them under this Act, and any license, order, or special Act is used: Provided always that no local authority, company, or person shall be at liberty to use any form of lamp or burner or to use the electricity supplied to them for any purposes, or to deal with it in any manner so as to unduly or improperly interfere with the supply of electricity supplied to any other local authority, company, or person by the undertakers, and if any dispute or difference arises between the undertakers and any local authority, company, or person entitled to be supplied with electricity under this Act, or any license, order, or special Act, as to the matters aforesaid, such dispute or difference shall be determined by arbitration.

Under sec. 18 of the Gasworks Clauses Act, 1847, 10 Vict. c. 15, the gas companies have a right to prescribe the form of burner to be used. This they seldom or never do. The reason of the proviso was that in those days gas meters had not been invented. Page 58.

But the Electric Lighting Act entirely forbids the prescribing of any form of burner, or even of the use to which the electricity shall be put. Undertakers, therefore, who are unprovided with an electric meter, will be obliged to bargain with a consumer as to the smallest resistance that shall be allowed in his house, by which of course the maximum current is fixed.

The second part of this section is of great importance, seeing how easy it is for any one consumer in a circuit to interfere with the electric current, and derange all the lamps in the neighbourhood.

Obligation on undertakers to supply electricity.

19. Where a supply of electricity is provided in any part of an area for private purposes, then, except in so far as is otherwise provided by the terms of the license, order, or special Act authorising such supply, every company or person within that part of the area shall, on application, be entitled to a supply on the same terms on which any other company or person in such part of the area is entitled under similar circumstances to a corresponding supply.

Note the use of the words "private purposes," and compare with sec. 3 subsecs. 3 and 4, which includes under private purposes the supply for any purpose other than lighting.

In the earlier Gas Acts, the undertakers were under no compulsion to supply electricity. This provision was first generally introduced by the Gasworks Clauses Act, 1871, 34 and 35 Vict. c. 41.

Page 98. See the Chelsea Provisional Order, clauses 49-52.

Charges for electricity.

20. The undertakers shall not, in making any agreements for a supply of electricity, show any undue preference to any local authority, company, or person, but, save as aforesaid, they may make such charges for the supply of electricity, as may be agreed upon, not exceeding the limits of price imposed by or in pursuance of the license, order, or special Act authorising them to supply electricity.

(The limits allowed them will in general be high; see paragraph 6 of the Memorandum of the Board of Trade, Feb. 26, p. 96.)

At present in London the maximum prices range from 70s. to 60s.per unit of 1,000 Volt-Ampère-hours. See Chelsea Provisional Order, clause 49, and the chapter on Cost of Electric Lighting.

These "undue preference" clauses are now being constantly imposed in return for special powers. But it is not a common law liability. See *Hungerford Market* v. *City Steamboat Company* (1860), 3 Ell. and Ell. 365. What would be considered "undue" is a question of fact in each case. If the section is interpreted on the same lines as the railway undue clauses, it will receive a wide meaning, and the undertakers will not be allowed to favour themselves any more than to favour others. Thus, if they were to undertake to supply electricity at a given price, and lamps free of cost, this would probably be held undue, as in the case of *Baxendale* v. *Great Western Railway*, 5 *C.B. N.S.* 336. Here it had been customary for a railway company to charge 3s. 6d. per ton for the carriage of goods, and 4s. 10d. for collecting and delivering them. This collection and delivery was, however, done by private firms as well as by the railway company. To destroy this competition, the railway company raised their carrying charge to 4s. 10s. + 3s. 6d. = 8s. 4d.

and offered to do the collecting and delivering for nothing. Held an undue preference. What is forbidden seems to be not an accidental advantage, given to some persons, but what may be termed intentional favouritism.

Recovery of charges, &c.

21. If any local authority, company, or person neglect to pay any charge for electricity or any other sum due from them to the undertakers in respect of the supply of electricity to such local authority, company, or person, the undertakers may cut off such supply, and for that purpose may cut or disconnect any electric line or other work through which electricity may be supplied, and may, until such charge or other sum, together with any expenses incurred by the undertakers in cutting off such supply of electricity as aforesaid, are fully paid, but no longer, discontinue the supply of electricity to such local authority, company, or person.

Pages 49 and 60.

This section, together with the sections 16, 17 and 40 of the Gasworks Clauses Act, 1847 (10 Vict. c. 15), and the Gasworks Clauses Act, 1871, 34 & 35 Vict. c. 41, secs. 39 and 40, 41 and 42, provides the undertakers with easy means of recovering the rent due to them for the use of electricity and the hire of meters. The combined effect of them is to enable the undertakers, in default of payment of any sum due to them, to enter the premises, after twenty-four hours' notice, between 9 a.m. and 4 p.m., and cut off the supply till it is paid, and then to recover the rent due for the electricity, together with the cost of cutting it off, in a summary manner, as a civil debt, under the Summary Jurisdiction Act, 1879 (42 & 43 Vict. c. 49, secs. 6, 35), without prejudice, however, to their rights to regard any sums due to them as ordinary contract debts. (Gasworks Clauses Act, 1871, sec. 41.)

Injuring works with intent to cut off supply of electricity.

22. Any person who unlawfully and maliciously cuts or injures any electric line or work with intent to cut off any supply of electricity shall be guilty of felony, and be liable to be kept in penal servitude for any term not exceeding five years, or to be imprisoned with or without hard labour for any term not exceeding two years; but nothing in this section shall exempt a person from any proceeding for any offence which is punishable under any other provision of this Act, or under any other Act, or at common law, so that no person be punished twice for the same offence.

See note to section 23.

Stealing electricity.

23. Any person who maliciously or fraudulently abstracts,

causes to be wasted or diverted, consumes, or uses any electricity, shall be guilty of simple larceny and punishable accordingly.

Gas may at Common Law be the subject of larceny. This was always admitted. In *R.* v. *White* (1853) 1 C. L. R. 489, 22 L. J. M. C. 123, the question was raised whether the thief could be said to have "carried away" the gas so as to complete the "asportavit." The court held, that to turn it on and let it flow into his burner was a sufficient "carrying away." The taking would be a continuous taking day after day, notwithstanding the gas was turned off at night. *Reg.* v. *Firth* (1869) L. R. 1 C. C. R. 172. 38 L. J. M. C. 54.

The enactments relative to the theft or misuse of electricity or meters are as follows :—

1. Larceny of electricity, E. L. Act, 1882, sec. 23.
2. Malicious injury to lines or works with intent to cut off the supply, E. L. Act, 1882, sec. 22.
3. Fraudulently injuring meters, or improperly using electricity, Gasworks Clauses Act, 1847, 10 Vict. c. 15. sec. 18. Page 58.
4. Wilful injury or waste, ibid., sec. 19.
5. Satisfaction to the undertakers for carelessness or accident, ibid., sec. 20.
6. Improper use of electric burners or lamps forbidden, E. L. Act, 1882, sec. 18.
7. Wilful, fraudulent, or negligent injury to lines, meters, or fittings, or fraudulent abstraction of electricity, Gasworks Clauses Act, 1871. 34 and 35 Vict. c. 41. sec. 38. Page 60.

In addition to this, the civil and criminal law may be invoked, and an action maintained for damage to wires, or an indictment or information laid for malicious injury to property.

Power to enter lands or premises for ascertaining quantities of electricity consumed, or to remove fittings, &c.

24. Any officer appointed by the undertakers may at all reasonable times enter any premises to which electricity is or has been supplied by the undertakers, in order to inspect the electric lines, meters, accumulators, fittings, works, and apparatus for the supply of electricity belonging to the undertakers, and for the purpose of ascertaining the quantity of electricity consumed or supplied, or where a supply of electricity is no longer required, or where the undertakers are authorised to take away and cut off the supply of electricity from any premises, for the purpose of removing any electric lines, accumulators, fittings, works, or apparatus belonging to the undertakers, repairing all damage caused by such entry, inspection, or removal.

Pages 57 and 60.

This section is of much the same effect as sections 15 and 17 of the Gasworks Clauses Act, 1847 (10 Vict., c. 15). This had been previously amended by sec. 21 of the Gasworks Clauses Act, 1871 (34 and 35 Vict., c. 41) which is, however, not incorporated with the Electric Lighting Act,

1882. The different modes of measuring electricity will be found discussed in the second part of this work.

Electric lines, &c. not to be subject to distress in certain cases.

25. Where any electric lines, meters, accumulators, fittings, works, or apparatus belonging to the undertakers are placed in or upon any premises not being in the possession of the undertakers for the purpose of supplying electricity under this Act, or any license, order, or special Act, such electric lines, meters, accumulators, fittings, works, or apparatus shall not be subject to distress or to the landlord's remedy for rent of the premises where the same may be, nor to be taken in execution under any process of a court of law or equity, or any proceedings in bankruptcy against the person in whose possession the same may be found.

Page 56.

Compare with the narrower terms of the Gasworks Clauses Act, 1847, (10 Vict., c. 15) sec. 14. The wide words of this section protect entirely the property of the undertakers placed on premises not in their possession for the purpose of supplying electricity. The principle which underlies the question whether things are or are not "fixtures," and hence whether they are or are not liable to distress, depends on the intention of the person fixing them, not as that intention actually was, but as it must be presumed to have been from the mode in which the things were placed on the premises.

This consideration would serve to show that gas meters could hardly be called fixtures, and this had been so decided as far as rating is concerned, see *Reg.* v. *Inhabitants of Lee* (1866) *L. R.* 1 *Q. B.*, 241.

Provision for protection of the Postmaster-General.

41 & 42 Vict. c. 76.

Page 65.

26. No alteration* in any telegraph line of the Postmaster-General shall be made by the undertakers except subject to the provisions of the Telegraph Act, 1878.

The undertakers shall not, in the exercise of the powers conferred by this Act, or by any license, order, or special Act, lay down any electric line, or do any other work for the supply of electricity whereby any telegraphic line of the Postmaster-General is or may be injuriously affected, and before any such electric line is laid down or work is done within ten yards of any part of a telegraphic line of the Postmaster-General (other than repairs or the laying of connexions with mains where the direction of the electric lines so laid down crosses the line of the Postmaster-General at right angles at the point of shortest distance, and continues the same for a distance of six feet on each side of such point), the undertakers or their agents, not more than twenty-

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* Note the definitions of these words in sec. 2 of the Telegraph Act, 1878 (41 and 42 Vict. cap. 76).

Sec. 26.

eight nor less than seven clear days before commencing such work, shall give written notice* to the Postmaster-General, specifying the course and nature of the work, including the gauge of any electric lines; and the undertakers and their agents shall conform with such reasonable requirements, either general or special, as may from time to time be made by the Postmaster-General for the purpose of preventing any telegraphs of the Postmaster-General from being injuriously affected by the said work.

Any difference which arises between the Postmaster-General and the undertakers or their agents with respect to any requirements so made, shall be determined by arbitration.

In the event of any contravention of or wilful non-compliance with this section by the undertakers or their agents, the undertakers shall be liable to a fine not exceeding ten pounds for every day during which such contravention or non-compliance continues, or, if the telegraphic communication is wilfully interrupted, not exceeding fifty pounds for every day on which such interruption continues.

Provided that nothing in this section shall subject the undertakers or their agents to a fine under this section, if they satisfy the court having cognizance of the case that the immediate execution of the work was required to avoid an accident, or otherwise was a work of emergency, and that they forthwith served on the postmaster or sub-postmaster of the postal telegraph office nearest to the place where the work was done, a notice of the execution thereof, stating the reason for executing the same without previous notice.

For the purposes of this section, a telegraphic line of the Postmaster-General shall be deemed to be injuriously affected by a work if telegraphic communication by means of such line is, whether through induction or otherwise, in any manner affected by such work, or by any use made of such work.

For the purposes of this section, and subject as therein provided, sections two, seven, eight, nine, ten, eleven, and twelve of the Telegraph Act, 1878, shall be deemed to be incorporated with this Act, as if the undertakers were undertakers within the meaning of those sections, without prejudice nevertheless to any operation which the other sections of the said Act would have had if this section had not been enacted.

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* The notice prescribed in this section is different from and in lieu of that in the Telegraph Act, 1878, sec. 7 (1), and is further modified by the provisions in the Chelsea Provisional Order, clause 12, and clause 16 is designed to protect all telegraphs and telephones whatsoever.

The provisions of this section, taken together with the Telegraph Act, 1878 (p. 65), are substantially as follows:

The undertakers must in no case injuriously affect any of the lines of the Postmaster-General.

If they intend to approach within ten yards of a telegraph line of the Postmaster-General (except for repairs, or an electric connexion with a main at right angles to the telegraph line for a distance of at least six feet on either side of it), they must, except in cases of emergency, give notice to him, and conform to his reasonable requirements. In default of agreement the matter will be referred to arbitration (see Electric Lighting Act, sec. 28).

Purchase of undertaking by local authority.

27. Where any undertakers are authorised by a provisional order or special Act to supply electricity within any area, any local authority within whose jurisdiction such area or any part thereof is situated may, within six months after the expiration of a period of twenty-one years, or such shorter period as is specified in that behalf in the application for the provisional order or in the special Act, from the date of the passing of the Act confirming such provisional order, or of such special Act, and within six months after the expiration of every subsequent period of seven years, or such shorter period as is specified in that behalf in the application for the provisional order or in the special Act, by notice in writing require such undertakers to sell, and thereupon such undertakers shall sell to them their undertaking, or so much of the same as is within such jurisdiction, upon terms of paying the then value of all lands, buildings, works, materials, and plant of such undertakers suitable to and used by them for the purposes of their undertaking within such jurisdiction, such value to be in case of difference determined by arbitration: Provided that the value of such lands, buildings, works, materials, and plant shall be deemed to be their fair market value at the time of the purchase, due regard being had to the nature and then condition of such buildings, works, materials, and plant, and to the state of repair thereof, and the suitability of the same to the purposes of the undertaking, and, where a part only of the undertaking is purchased, to any loss occasioned by severance; but without any addition in respect of compulsory purchase or of goodwill or of any profits which may or might have been or be made from the undertaking, or of any similar considerations.

The Board of Trade may determine any other question which may arise in relation to such purchase, and may fix the date from which such purchase is to take effect, and from and after the date so fixed, or such other date as may be agreed upon betwen the parties, all lands, buildings, works, materials, and plant so purchased as aforesaid shall vest in the local authority which has made the purchase, freed from any debts, mortgages, or similar obligations of such undertakers or attaching to the undertaking, and the powers of such undertakers in relation to the supply of electricity under this Act or such provisional order or special Act as aforesaid within such area or part thereof as aforesaid shall absolutely cease and determine, and shall vest in the local authority aforesaid.

Compare with the Chelsea Provisional Order, clause 75. This is a stringent section, giving the mere market value of the property, without anything for the goodwill. This provision does not apply to licenses, but under a license the undertakers would not be much better off, for it lasts only seven years, and the local authority might refuse to consent to its renewal, and thus practically sacrifice the undertaking, or compel the undertakers to sell to them at a loss. In such a case the undertaker's only remedy would be to apply for a provisional order.

Arbitration.

28. Where any matter is by this Act, or any license, order, or special Act, directed to be determined by arbitration, such matter shall, except as otherwise expressly provided, be determined by an engineer or other fit person to be nominated as arbitrator by the Board of Trade on the application of either party, and the expenses of the arbitration shall be borne and paid as the arbitrator directs.

37 & 38 Vict. c. 40. Page 62.

Any license or provisional order granted under this Act shall be deemed to be a special act within the meaning of the Board of Trade Arbitrations, &c., Act, 1874.

The various matters left to the arbitration of the Board of Trade are as follows:—

E. L. Act, sec. 15. The compensation to be made to owners of pipes and wires broken up by undertakers.
,, sec. 16. As to rights of owners of canals, docks, &c.
,, sec. 17. For all damage done by the undertaking, see also Gas Clauses Act, 1847, (10 Vict. c. 15.) sec. 6.
,, sec. 18. Disputes as to the proper use of electricity by consumers.
,, sec. 26. Where the Postmaster-General is concerned.
,, sec. 27. Purchase of undertaking by local authority.

The Board of Trade Arbitrations Act is printed at p. 62.

Its provisions are (shortly) as follow :—

They have powers to hold such inquiries as they think fit, (sec. 2) and of appointing arbitrators, referees, and persons to report, and may direct by whom the expenses of such references shall be paid, and recover them as a civil debt (sec 3). In cases where a railway company is a party to a dispute, the matter may go before the Railway Commissioners (secs. 6, 7, 8).

Power for Board of Trade to relieve gas undertakers from obligation to supply gas in certain cases.

29. Where a supply of electricity is authorised in any area by any license, order, or special Act, and a supply of gas by any gas undertakers is also authorised within such area or any part thereof by any provisional order or special Act under the provisions of which such gas undertakers are under any general or limited obligation to supply gas upon demand, the Board of Trade may, upon the application of such gas undertakers, inquire into the circumstances of the case, and if they are satisfied that any specified part of such area is sufficiently supplied with electric light, and that the supply of gas in such specified part has ceased to be remunerative to the gas undertakers, and that it is just that such gas undertakers should be relieved from the obligation to supply gas upon demand as aforesaid, the Board of Trade may in their discretion make an order relieving the gas undertakers from such obligation, within such specified part of such area, either wholly or in part, and upon such terms and conditions as they may think proper; and from and after the date of such order such gas undertakers shall be so relieved accordingly. All expenses of the Board of Trade in connexion with any such inquiry or order shall be borne and paid by the gas undertakers upon whose application the inquiry or order was made.

The gas companies are at present under obligation to supply the public lamps within fifty yards, and private consumers within twenty-five yards of the mains, and to charge such prices as may be determined by arbitration, regard being had to their profits, not exceeding ten per cent.

They will be released from these obligations if the district is sufficiently supplied with electric light, and if the gas supply has ceased to be remunerative. The fact that the supply of gas might be much desired for heating and cooking is not taken into account, nor for those purposes can the gas companies be compelled to work at a loss.

Annual report by Board of Trade.

30. Not later than the first day of July in each year the Board of Trade shall lay before both Houses of Parliament a report respecting the applications to and proceedings of the Board of Trade under this Act during the year then last past.

Definition of local authority, &c.

31. In this Act, unless the context otherwise requires, the expressions "local authority" and "local rate" mean, as respects each district set forth in the first column of the schedule to this Act annexed, the authority and rate mentioned opposite to that district in the second and third columns of that schedule; and such schedule, and the notes appended thereto, shall be of the same validity as if enacted in the body of the Act.

See the notes to the schedule, p. 46.

Interpretation.

32. In this Act, unless the context otherwise requires—

The expression "electricity" means electricity, electric current, or any like agency:

The expression "electric line" means a wire or wires, conductor, or other means used for the purpose of conveying, transmitting, or distributing electricity with any casing, coating, covering, tube, pipe, or insulator enclosing, surrounding, or supporting the same, or any part thereof, or any apparatus connected therewith for the purpose of conveying, transmitting, or distributing electricity or electric currents:

The expression "works" means and includes electric lines, also any buildings, machinery, engines, works, matters, or things of whatever description required to supply electricity, and to carry into effect the object of the undertakers under this Act:

The expression "company" means any body of persons corporate or unincorporate:

8 & 9 Vict. c. 18. 23 & 24 Vict. c. 106. 32 & 33 Vict. c. 18.

The expression "Lands Clauses Acts" means the Lands Clauses Consolidation Acts, 1845, 1860, and 1869:

The expression "street" includes any square, court, or alley, highway, lane, road, thoroughfare, or public passage, or place, within the area in which the undertakers are authorised to supply electricity by this Act, or any license, order, or special Act:

32 & 33 Vict. c. 73.

The expression "telegram" has the same meaning as in the Telegraph Act, 1869.

See the note to the word "street," appended to sec. 7 of the Gasworks Clauses Act, 1847, p. 49.

For the protection of mines.

33. Nothing in this Act shall limit or interfere with the rights of any owner, lessee, or occupier of any mines or minerals lying under or adjacent to any road along or across which any electric line shall be laid to work such mines and minerals.

Provision to general Acts.

34. Nothing in this Act shall exempt the undertakers or their undertaking from the provisions of any general Act relating to the supply of electricity which may be passed in this or any future session of Parliament.

This clause for greater caution is repeated in the Chelsea Provisional Order, clause 79.

Saving for privileges of Postmaster-General.

35. Nothing in this Act or in any license, order, or special Act, shall affect the exclusive privileges conferred upon the Postmaster-General by the Telegraph Act, 1869, or authorise or enable any local authority, company, or person to transmit any telegram, or to perform any of the incidental services of receiving, collecting, or delivering telegrams, or give to any local authority, company, or person, any power, authority, or facility of any kind whatever, in connexion with the transmission of telegrams, or the performance of any of the incidental services of receiving, collecting, or delivering telegrams.

As to Scotland.

Application of Act to Scotland.

36. This Act shall apply to Scotland with the following modifications:

The expression "Lands Clauses Acts" means the Lands Clauses Consolidation (Scotland) Acts, 1845 and 1860.

8 & 9 Vict. c. 19.
23 & 24 Vict. c. 106.

The expression "simple larceny" means theft.

The expression "felony" means a high crime and offence.

The expression "public purposes" means lighting any street or any place belonging to or subject to the control of any public authority, or any church or place of public worship, or any hall or building belonging to or subject to the control of any public authority, or any public theatre, but shall not include any other purpose to which electricity may be applied.

The expression "local authority" means, as regards streets and roads, the authority having the control of the streets and roads.

As to Ireland.

Application of Act to Ireland.

37. This Act shall apply to Ireland with the following modifications:

Where the consent of the grand jury of any county to the breaking up of any road is required under this Act, such consent may be signified by the county surveyor; and where it is required under this Act that notice should be given by the Board of Trade to the grand jury of any county, and an opportunity afforded to such grand jury to state objections, such notice may be given to, and such objections may be stated by, the county surveyor on behalf of the grand jury:

41 & 42 Vict. c. 52. The expression "Public Health Act, 1875," means the Public Health (Ireland) Act, 1878.

See note to the schedule.

The reason of the enactment as to the consent of the grand jury is because in the country in Ireland the Highway Authority is not the Local Sanitary Authority, neither are there Highway Boards, but the grand jury, under 6 and 7 Will. IV., c. 116, and various amending statutes, is entrusted with the duty of repairing the roads, which duty is carried out by a surveyor. The grand jury system of Ireland is far more like a county government than the grand jury in England. In the times of the Protestant ascendency in Ireland, the grand jury generally consisted of Englishmen, who, when they met the judges on their assize circuits, were also utilised for the purpose of local Government. The grand jury is not a representative body, and the important institution known as the English Parish has never existed in Ireland.

SCHEDULE.

Showing the Local Authorities for Electric Lighting purposes, and their powers (see sections 8 *and* 31 *of the Electric Lighting Act,* 1882), *and note also that the Local Authorities of districts to which the Local Loans Act applies* (38 *and* 39 *Vict. c.* 83), *may borrow as therein provided.*

Districts of Local Authorities.	Description of Local Authority of District set opposite its Name.	The Local Rate.	Security upon which Loans are to be contracted.	Authority whose Consent is required to borrowing by Local Authority.	Provisions and Restrictions as to borrowing and the Repayment of Loans.	Mode of Audit of Accounts of Local Authority.
			ENGLAND AND WALES.			
The City of London and the liberties thereof (*defined by* 11 *and* 12 *Vict. c.* 163).	The Mayor, Commonalty, and Citizens acting by the Commissioners of Sewers.	The consolidated sewers rate (*see* 11 *and* 12 *Vict. c.* 163, *secs.* 168-206).				
Parts of the metropolis which the Metropolitan Board of Works are authorised to light.	The Metropolitan Board of Works (18 *and* 19 *Vict. c.* 120).	The consolidated rate (*see* 32 *and* 33 *Vict. c.* 102 *sec.* 22).				
Parish mentioned in Schedule A. to the Metropolis Management Act, 1855 (18 *and* 19 *Vict. c.* 120 *page* 73).	The vestry (18 *and* 19 *Vict. c.* 120, *sec.* 1).	The lighting rate or other fund or rate applicable for lighting (18 *and* 19 *Vict. c.* 120, *sec.* 161, 165).	The local rate as herein defined.	The Metropolitan Board of Works (*constituted* 18 *and* 19 *Vict. c.* 120, *sec.* 43).	Those contained in sections one hundred and eighty-three to one hundred and ninety-one (both inclusive) of the Metropolis Management Act, 1855 (18 *and* 19 *Vict. c.* 120).	That prescribed by section one hundred and ninety-five of the Metropolis Management Act, 1855 (18 *and* 19 *Vict. c.* 120).
District mentioned in Schedule B. to the Metropolis Management Act, 1855.	The district board (18 *and* 19 *Vict. c.* 120, *sec.* 31).					

ENGLAND AND WALES—*continued.*

Districts of Local Authorities.	Description of Local Authority of District set opposite its Name.	The Local Rate.	Security upon which Loans are to be contracted.	Authority whose Consent is required to borrowing by Local Authority.	Provisions and Restrictions as to borrowing and the Repayment of Loans.	Mode of Audit of Accounts of Local Authority.
Urban sanitary district (1).	The urban sanitary authority (1).	The fund or rate applicable to the general purposes of the Public Health Act, 1875, in the district, or any other fund or rate applicable to lighting under any local Act (38 *and* 39 *Vict.* c. 55. *secs.* 207-212).	The local rate as herein defined and any property of the local authority.	The authority whose consent is required to loans under section two hundred and thirty-three of the Public Health Act, 1875 (38 *and* 39 *Vict.* c. 55).	Those contained in sections two hundred and thirty-three, two hundred and thirty-four, and two hundred and thirty-six to two hundred and thirty-nine (both inclusive) of the Public Health Act, 1875 (38 *and* 39 *Vict.* c. 55).	In the case of boroughs (2), that prescribed by section two hundred and forty-six of the Public Health Act, 1875, and in the case of other urban sanitary authorities that prescribed by section two hundred and forty-seven of the same Act (38 *and* 39 *Vict.* c. 55).
Rural sanitary district (1).	The rural sanitary authority (1).	The rate or rates out of which special expenses incurred in respect of the contributory place or places (1) comprised within the area of supply are payable under the Public Health Act, 1875 (38 *and* 39 *Vict.* c. 55, *secs.* 229, 230, 231).	The local rate as herein defined.	The authority whose consent is required to loans under section two hundred and thirty-three of the Public Health Act, 1875 (38 *and* 39 *Vict.* c. 55).	Those contained in sections two hundred and thirty-three, two hundred and thirty-four, and two hundred and thirty-six to two hundred and thirty-nine (both inclusive) of the Public Health Act, 1875 (38 *and* 39 *Vict.* c. 55).	That prescribed by section two hundred and forty-eight of the Public Health Act, 1875 (*see also* 42 *Vict.* c. 6).

NOTES.

(1) "Urban sanitary district," "urban sanitary authority," "rural sanitary district," "rural sanitary authority," and "contributory place," have the meanings respectively assigned to them in the Public Health Act, 1875. (38 and 39 Vict. c. 55, secs. 5, 6, 9.)

(2) "Borough" means any place for the time being subject to an Act passed in the session holden in the fifth and sixth years of the reign of King William the Fourth, chapter seventy-six, intituled, "An Act to provide for the Regulation of Municipal Corporations in England and Wales," and the Acts amending the same.

(*N.B. The above notes* (1) *and* (2) *are by parliamentary authority, and form part of the Schedule.*

Districts of Local Authorities.	Description of Local Authority of District set opposite its name.	The Local Rate.	Security upon which Loans are to be contracted.	Authority whose consent is required to borrowing by Local Authority.	Provisions and Restrictions as to borrowing and the Repayment of Loans.	Mode of Audit of Accounts of Local Authority.
			SCOTLAND			
Places within the jurisdiction of any town council, and not subject to any such separate jurisdiction as hereinafter mentioned.	The town council (*see* 30 *and* 31 *Vict.* c. 101 *sec.* 5).	The police or burgh assessment, or rate of the nature of a burgh assessment (*see* 30 *and* 31 *Vict.* c. 101 *sec.* 93).	The local rate as herein defined.	One of Her Majesty's Principal Secretaries of State.	Those contained in section eighty-six of the Public Health (Scotland) Act, 1867 (30 *and* 31 *Vict.* c. 101 *sec.* 86).	That prescribed by sections seventy-seven and seventy-eight of the General Police and Improvement (Scotland) Act, 1862, provided that the expression "Commissioners" shall include town council (25 *and* 26 *Vict.* c. 101 *secs.* 77 *and* 78).
Places within the jurisdiction of police commissioners or trustees exercising the functions of police commissioners under any general or local Act, and not subject to such jurisdiction as hereinafter mentioned.	The police commissioners or trustees (30 *and* 31 *Vict.* c. 101 *sec.* 5).					
Places within the jurisdiction or limits of any public commissioners or board (other than any of the bodies hereinbefore mentioned) charged by any local Act with the duty of lighting the district within their jurisdiction or limits with gas.	The commissioners or board.	The gas rates leviable by the commissioners or board.	The local rate as herein defined, and the rates, charges, and other securities provided by the local Act.	One of Her Majesty's Principal Secretaries of State.	Those contained in the local Act with respect to the borrowing of money for the purposes thereof.	That prescribed by the local Act.

SCOTLAND—*continued.*

Districts of Local Authorities.	Description of Local Authority of District set opposite its Name.	The Local Rate.	Security upon which Loans are to be contracted.	Authority whose consent is required to borrowing by Local Authority.	Provisions and Restrictions as to borrowing and the Repayment of Loans.	Mode of Audit Accounts of Local Authority.
Any county or part thereof over which the jurisdiction of a town council or of police commissioners or trustees exercising the functions of police commissioners does not extend, and not within the jurisdiction or limits of such public commissioners or board as above mentioned.	The County road board (41 *and* 42 *Vict. c.* 51 *secs.* 12-15).	The county road assessment (41 *and* 42 *Vict. c.* 51 *sec.* 52 *and* 82-85).	The local rate as herein defined.	One of Her Majesty's Principal Secretaries of State.	Those contained in sections seventy-five to seventy-nine, both inclusive, of the Roads and Bridges (Scotland) Act, 1878 (41 *and* 42 *Vict. c.* 51 *secs.* 75-79 ; 120).	That prescribed by section one hundred and twenty of the Roads and Bridges (Scotland) Act, 1878 (41 *and* 42 *Vict. c.* 51).
			IRELAND.			
Urban sanitary district (1).	The urban sanitary authority (1).	The rate or rates applicable to the general purposes of the Public Health (Ireland) Act, 1878, or any other fund or rate applicable to lighting under any Local Act (41 *and* 42 *Vict. c.* 52, *secs.* 226-232).	The local rate as herein defined.	The authority whose consent is required to loans under section two hundred and thirty-seven of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).	Those contained in sections two hundred and thirty-seven, two hundred and thirty-eight, and two hundred and forty to two hundred and forty-three (both inclusive) of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).	That prescribed by section two hundred and forty-eight of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).

NOTE.

(1) "Urban sanitary district," "urban sanitary authority," "rural sanitary district," "rural sanitary authority," and "contributory place," have the meanings respectively assigned to them in the Public Health (Ireland) Act, 1878 (41 and 42 Vict. c. 52, secs. 3, 4, 5).

N.B. The above note forms part of the Schedule.

IRELAND—*continued.*

District of Local Authorities.	Description of Local Authority of District set opposite its Name.	The Local Rate.	Security upon which Loans are to be contracted.	Authority whose consent is required to borrowing by Local Authority.	Provisions and Restrictions as to borrowing and the Repayment of Loans.	Mode of Audit of Account of Local Authority.
Rural sanitary district (1).	The rural sanitary authority (1).	The rate or rates out of which special expenses incurred in respect of the contributory place or places (1) comprised within the area of supply are payable under the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52, *secs.* 232, 233).	The local rate as herein defined.	The authority whose consent is required to loans under section two hundred and thirty-seven of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).	Those contained in sections two hundred and thirty-seven, two hundred and thirty-eight, and two hundred and forty to two hundred and forty-three (both inclusive) of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).	That prescribed by section two hundred and forty-eight of the Public Health (Ireland) Act, 1878 (41 *and* 42 *Vict. c.* 52).

NOTE.

(1) "Urban sanitary district," "urban sanitary authority," "rural sanitary district," "rural sanitary authority," and "contributory place," have the meanings respectively assigned to them in the Public Health (Ireland) Act, 1878 (41 and 42 Vict, c. 52, secs. 3, 4, 6).

N.B. The above note forms part of the Schedule.

Local Authorities. **Page 41.** The local authorities for England are as follows. (See Electric Lighting Act, 1882, schedule.) For the City of London, the mayor and corporation; for the Victoria Thames Embankment, and Waterloo Station, &c. which, under special Acts the Metropolitan Board of Works are authorised to light; the Metropolitan Board of Works are the local authority. For the rest of the metropolis, the parish vestries mentioned in Schedule A of the Metropolis Management Act, 1855, or those agglomerations of parishes which have been formed into metropolitan district boards, and are enumerated in schedule B of the same Act.

For the remainder of England the local authorities are the same as those to whom under the Public Health Acts the sanitary condition of the country is entrusted.

38 & 39 Vict. c. 55. These sanitary authorities are defined by the Public Health Act, 1875, which gathered up into a code a vast number of previously existing isolated statutes. For boroughs, the local authority is the mayor, aldermen, and burgesses as represented by the council. By special Acts, certain improvement districts had been created in various parts of England, and entrusted to improvement commissioners. These districts were continued under the Public Health Act, 1875, which also continues such districts as had been subjected to local boards constituted under the Local Government Acts. These three kinds of authorities, for Boroughs, Improvement-Act Districts, and Local Government Districts respectively, are grouped together under the head of urban sanitary authorities, acting in urban sanitary districts which embrace the chief towns in England.

The country is placed under the care of rural sanitary authorities, usually the boards of guardians of the union, and acting in rural districts formed out of the unions.

It will be remembered that poor relief was first administered in England by means of parishes, and that in 1834, to promote economy, parishes were grouped into unions. These unions included portions of towns, and for the purposes of poor relief they still do so. But the rural districts under the Public Health Act, 1875, though they are based on the union districts, do not comprise the whole of them, only such parts of the unions as are not occupied by the urban sanitary districts.

And the rural sanitary districts so constituted, remain divided into parishes, and in some cases into another creature of statute, called special drainage districts. These divisions of rural sanitary districts are called "contributory places."

Before the Electric Lighting Act the urban sanitary authorities had lighting powers under secs. 161-163 of the Public Health Act, 1875, and the various lighting commissioners had very limited powers under the Watching and Lighting Act, 3 and 4 Will. IV. c. 90. Facilities had also been afforded to borough authorities improvement-commissioners, local boards, and vestries, to undertake gas lighting, and by two Acts, the Gas and Water Works Facilities Acts of 1870 and 1873 (33 & 34 Vict. c. 70; 36 & 37 Vict. c. 89) these several bodies had been enabled to apply to the Board of Trade for pro-

Local Authorities.

visional orders, which when granted, incorporated the Gas Works Clauses Acts with regard to the breaking up of streets, recovery of charges, &c., and practically placed them in the position of gas companies with special statutory powers. Apart however from special statute or provisional order, the sanitary authorities have no power to break up streets, or to allow others to do so, whether for gaslighting or any other purpose.

The Electric Lighting Act has been framed much on the same lines as the Gas and Water Works Facilities Act, its object being to give both to urban and rural sanitary authorities and others, even wider powers than those which could be bestowed under the Gas and Water Works Facilities Acts, and which are worth consulting on account of their similarity to the Electric Lighting Act.

In order to defray the expenses of these undertakings, urban and rural sanitary authorities had powers to levy rates (P. H. Act, 1875, part vi., secs. 207-232; and contract loans (P. H. Act, 1875, secs. 233-250; and Local Loans Act, 1875). These powers they have also under the Electric Lighting Act (secs. 7 and 8, and schedule).

The urban authorities are directed to pay the expenses of electric lighting out of their borough fund or rate, or out of the district fund or general district rate (P. H. A. secs. 207-212, 218-228), which, however, may be apportioned amongst different parts of the district. In general, therefore, each part of an urban district can be made to pay for its own electric lighting.

The rural authorities are to treat electric lighting as a "special expense," and levy it as a separate charge on each contributory place, as provided by secs. 229-231. In general, therefore, each parish will bear its own expenses.

The borrowing powers of the urban and rural sanitary authorities are contained in the Electric Lighting Act, 1882, sec. 8, and schedule; and the P. H. Act, 1875, secs. 233, 234, 236-239. And if the Local Loans Act, 1875, (38 and 39 Vict. c. 83) extends to the district, then that Act is also available (Electric Lighting Act, 1882, sec. 8). The principal conditions are, that the works to be erected with the borrowed money shall be permanent, that the total debt on a district shall not exceed its assessable value for two years, and that the loan be repayable in not more than sixty years by annuities, or by a sinking fund. The repayment of moneys so borrowed may be enforced by the appointment of a receiver.

The above local authorities are sometimes, but not always, the authority by whom the roads are repairable. In urban districts, the sanitary authority is the highway authority; in rural districts the highway authority may or may not be the rural sanitary authority. For in the country the highways were originally repaired by parishes, many of which "parochial highway areas" still remain. Under various Acts, "highway districts" were formed out of these parishes by grouping them together, and by 41 & 42 Vict. c. 77, whenever a highway district is coincident in area with a rural sanitary district, Local Authorities.

the Quarter Sessions may, on the application of the rural sanitary authority, constitute it the highway authority. This has been largely done; hence while in towns the electric lighting local authority is always the highway authority, in the country the electric lighting authority may be the highway authority, provided such highway authority is not either the authority of some parochial area or combined highway district. In such cases the rules of sec. 13 of the Electric Lighting Act, 1882, would have to be carefully followed, and, if possible, the consent of the highway authority obtained.

In Scotland the local authorities for electric lighting are in general the road authorities of the districts. In burghs (by 41 & 42 Vict. c. 51, secs. 3 and 11) these are the sanitary authorities under the Public Health Act, 1867 (30 & 31 Vict. c. 101*), that is to say, the Town Councils or the Police Commissioners. In special lighting districts created by statute, the lighting authorities are the local authority. In the country in general, the local authority is the County Road Board, that is, a sort of committee chosen by the County Road Trustees, under the Roads Act, 1878 (41 and 42 Vict. c. 51), which consolidated the laws for the maintenance and repair of highways.

This Act was at first optional, but will become of universal application on June 1st, 1883 (secs. 4, 5).

The Public Health Act for Ireland (41 and 42 Vict. c. 52) closely resembles that for England. The electric lighting local authorities are, the urban and rural sanitary authorities, that is to say, (1) For the city of Dublin and corporate towns, the mayor and council. (2) For other towns, the commissioners under 9 Geo. IV. c. 7; the municipal commissioners under 3 and 4 Vict. c. 108; the towns commissioners under 17 and 18 Vict. c. 103; or the commissioners under some local Act. (3) For the country the rural sanitary authorities are the guardians of the unions.

The rating and borrowing powers are almost identical with those in England, and a short abstract of the chief provisions relating to them is printed further on p. 73.

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* Amended in details by 34 and 35 Vict. c. 38; 38 and 39 Vict. c. 74.

(The following are the Acts incorporated, or referred to, in the Electric Lighting Act, 1882.)

GASWORKS CLAUSES ACT, 1847.

10 Vict. Cap. XV.

An Act for consolidating in One Act certain Provisions usually contained in Acts authorising the making of Gasworks for supplying Towns with Gas.

[23rd *April*, 1847.

By sec. 12 of the Electric Lighting Act, 1882, are incorporated the provisions of 10 Vict. c. 15 with respect to breaking up streets for the purpose of laying (electric lines), and with respect to the waste or misuse of (electricity), or injury to the (electric lines) and other works (as defined by Electric Lighting Act, 1882, sec. 32); except so much as relates to the use of any burner other than such as have been provided or approved by the undertakers.

Note.—That sec. 12 engrafts a further interpretation clause—

For "gas" read "electricity."

For "pipe" read "electric wire."

For "works" read "works as defined by the Electric Lighting Act, 1882."

For "limits of the special Act" read, "the area within which the undertakers are authorised to supply electricity under any license, order, or special Act."

Laying of Pipes.

And with respect to the breaking up of streets for the purpose of laying pipes, be it enacted as follows:

Power to break up streets, &c. under superintendence, and to open drains.

VI. The undertakers, under such superintendence as is hereinafter specified (*a*), may open and break up the soil and pavement of the several streets (*b*) and bridges within the limits of the special Act, and may open and break up any sewers, drains, or tunnels, within or under such streets and bridges, and lay down and place within the same limits pipes, conduits, service pipes, and other works, and from time to time repair, alter, or remove the same, and also make any sewers that may be necessary for carrying off the washings and waste liquids which may arise in the making of the gas, and for the purposes aforesaid may remove and use all earth and materials in and under such streets and bridges, and they may in such streets erect any pillars, lamps, and other works and do all other acts which the undertakers shall from time to time deem

Laying of Pipes. Sec. 7.

necessary for supplying gas to the inhabitants of the district included within the said limits, doing as little damage as may be (*c*) in the execution of the powers hereby or by the special Act granted, and making compensation for any damage which may be done in the execution of such powers.

(*a*) See sec. 9. This section, as to electric lighting, is further extended by sec. 15 of the Electric Lighting Act, 1882, which enables undertakers to alter the position of pipes and wires which are in their way; subject, however, to the proviso that compensation is to be made and proper notice given, and subject to the further reciprocal condition that in like manner the wires of the undertakers may be altered by other authorities and persons.

Sec. 17 of the Electric Lighting Act, 1882, enlarges the last three lines of this Act, providing not only that as little damage as may be shall be done, and full compensation made, but also that as little detriment and inconvenience as may be shall be caused, and that the compensation is to be settled by arbitration. (See sec. 28 of Electric Lighting Act, 1882).

(*b*, *c*) *See notes which follow sec.* 7.

Not to enter on private land without consent.

VII. Provided always, That nothing herein shall authorise or empower the undertakers to lay down or place any pipe or other works into, through, or against any building (*d*), or in any land, not dedicated to public use, without the consent (*e*) of the owners and occupiers thereof; except that the undertakers may at any time enter upon and lay or place any new pipe in the place of an existing pipe in any land wherein any pipe hath been already lawfully laid down or placed in pursuance of this or the special Act or any other Act of Parliament, and may repair or alter any pipe so laid down.

This section, which is applied to electric lighting by sec. 12 of the Electric Lighting Act, 1882, is amended by sec. 13 of the same Act.

Notes to Sections 6 and 7.

(*b*) Under 6 and 7 of the incorporated sections of the Gasworks Clauses Act, 1847 (10 Vict. c. 15), and sec. 13 of the Electric Lighting Act, 1882, the electricity undertakers have powers to break up all streets, &c., within their area, provided that they do not put their wires into, through, or against any building or in any land not dedicated to public use. (See also the provisions of the Chelsea Provisional Order, clauses 12-18.)

With respect to the streets, &c., which are dedicated to public use, some are repairable by the local authority. These the undertakers may break up, subject to the provisions of their license or order; one of which may be that in certain cases the breaking up may be done by the local authority and charged to the undertakers. As to the streets, &c., which are not repairable by the local authority, the undertakers may break them up, if specially empowered to do so, either in their license or order, or with the consent of the Board of Trade; after due notice to the persons liable to repair them, that such powers are to be applied for by the undertakers. But it does not seem, having regard to sec. 7 above cited, that anything in sec. 13 could have been intended to empower the Board of Trade to allow private roads not dedicated to the public to be broken up, in spite of the word "private" in the marginal note to sec. 13. The true meaning is that the electricity undertakers are to be placed in much the same position as the gas companies.

It is, therefore, needful to inquire what is the meaning of the words "streets and bridges" in sec. 6 of the Gasworks Clauses Act, 1847, and what things are privileged from being broken up by sec. 77. And next it is necessary in dealing with the streets, which (being dedicated to the public) may be broken up under sec. 6, to distinguish those repairable by the local authority from those not so repairable. (Sec. 13 Electric Lighting Act, 1882.)

At common law the soil of the highway, that is, any portion of ground over which the public may pass, is the property of the adjoining owner, presumably up to the centre of the road, subject to the right of the King and his subjects o pass over it.

There were however reserved to the owner of the adjoining house, all rights consistent with the user of the highway by the public. Thus he might put gas and water-pipes underneath it, provided he did not break up the surface of the soil so as to interrupt the traffic, and he might, and still may, temporarily obstruct it for certain time-honoured purposes, as to take in goods and merchandize, and for putting up scaffolding for the purpose of repairs.

Highways can be made by dedication to the public, that is, by the owner throwing them open to public uses, and the public taking advantage of the dedication. The validity of the dedication depends on the intention of the person dedicating, and of the public in accepting the dedication, as evidenced by their respective acts. Thus no special length of user on the part of the public is essential, the length of user is only evidence, and if the act of dedication on the one hand, and the user on the other, are unequivocal, it may take place immediately. Thus if a man build a double row of houses opening into an ancient street at each end, making a street, and sell or let the houses, that is instantly a highway, *Woodyer* v. *Hadden* (1813), 5 Taunton 125.

When thus dedicated, the highway, like all other highways, became repairable by the parish, (per Blackburn, J., *Fawcett* v. *York and N. Midland Rail. Co.*, 16 Q. B. 614), except in some peculiar instances, as where certain corporations by ancient usage were bound "ratione tenuræ" to repair.

This state of the law was changed by the Highway Act, 1835, which provided that mere dedication of a highway to the public, and acceptance of the grant by public use should not throw the burden of repairing it on the public. Since that Act, it now becomes needful for one who has made a *roadway* for the improvement of an estate (a very common proceeding in towns), and desires to be relieved of the cost of repairing it, to give three months' notice in writing to the highway authority, in order that a meeting may be called to

Laying of Pipes. Sec. 7.

consider the proposal, and in case of difference the validity is to be determined by a court of summary jurisdiction.

Here then we may have an instance of a highway perfectly dedicated to the public and yet not repairable by them. But footways (not requiring special repair) are still repairable as at common law, as soon as the act of dedication is complete.

Generally speaking we may say, that those highways repairable by the local authorities are all those highways which existed before March 20, 1836 (5 and 6 Will. IV. c. 50); all cartways and driftways dedicated since then with the formal consent of the parish; all highways made by agreement between the owner of the soil and the urban sanitary authority (25 and 26 Vict. c. 61, sec. 36), and all public footways whatsoever.

Non-repairable highways are such dedicated roadways or horse roads as have been made since 1836, without having been accepted as repairable by the highway authorities, or which have been declared unnecessary, and not repairable, by a court of summary jurisdiction.

It has been said, that the soil of the highway belonged at common law to the owners. But by the Public Health Act, 1875 (38 and 39 Vict. c. 55) sec. 149, "streets" now "vest" in the local authority provided they are repairable by them, and this word street is so wide, as to include roads of all kinds. The effect of this word "vest" has been the subject of judicial decision, and gives the local authority a qualified ownership in the street, so long as it remains a highway, to such an extent as is necessary for the purpose of performing their duties with regard to it. See *Coverdale* v. *Charlton*, 3 Q. B. D. 376; 4 Q. B. D. 104, and *Rolls* v. *Vestry of St. George* (1880), 14 Ch. D. 785.

Apart from statute, a gas company cannot take up the streets, and an action or injunction lies to prevent them doing so, apart from the fine inflicted by 38 and 39 Vict. c. 55, sec. 149 (Public Health Act). But for every trivial disturbance a court will not interfere by injunction, especially where the local authority does not object, *Attorney-General* v. *Cambridge Consumers' Gas Company* (1868), L. R., 4 Ch. App. p. 71, 38 L. J., Ch. 94, and cases there cited.

Nor can a Highway Board enable them to do so. So that, if indicted, it is no answer to show the permission of the Highway Board, although in that case only a nominal fine would probably be inflicted. *Hawkins* v. *Robinson*, 37 J. P., 662. Nor is it any answer to show that a private owner of a house facing the highway authorised them. *Reg.* v. *Longton Gas Company* (1860), 2 Ell. and Ell. 651, and 29 L. J., M.C., 118. It was here argued that a private owner may for the enjoyment of his own property take up the street for a short time, as when he has coals delivered through a hole into his cellar. But the court negatived this view.

The word street is defined in the Gasworks Clauses Act, 1847, sec. 3, and also in sec. 32 of the Electric Lighting Act, 1882, as including "any square, court, alley, highway, lane, road, thoroughfare, or public passage or place."

There have been several decided cases on the meaning of the word street.

Laying of Pipes. Sec. 7.

The natural meaning, a roadway bounded by houses, was discussed by Lord Cranworth in *Galloway* v. *Mayor of London* (1866), L. R., 1 E. and I. Appeals, at p. 55. See also *London, Chatham, and Dover Railway Company* v. *Mayor of London* (1868), 19 L. T., n. s. 250. In *Le Neve* v. *the Vestry of Mile-End-Town*, it appeared that in the Mile-End-Road, in front of the houses, there was a paved footway. Between this footway and the carriage road there was an open strip of ground, over which the public had a right to pass, subject, however, to the right of the house occupiers opposite, to carry on their trades, as to put their goods there, to saw stone there, or to erect horse troughs and sheds. The vestry claimed to remove the sheds as an obstruction to a public street. Held, that though by the Metropolis Management Act, 19 and 20 Vict. c. 120, sec. 250, the word "street" had received a very wide possible meaning, yet that it did not include the ground between the footway and roadway. But note that the word "public place" is not in the 250th section above referred to, so that the definition in the Electric Lighting Act, 1882, is wider still.

But the word street above mentioned clearly means street over which the public have a right of way of some nature. Accordingly, in the case of *Case* v. *Storey* (1869), L. R. 4 Ex. 319, it was held under the Acts regulating cabs that the enclosure of a railway station was not a "public street or place." See also *Curtis* v. *Embery* (1872), L. R. 7 Ex. D. 369 and *Skinner* v. *Usher* (1872) L. R. 7, Q. B. 423, to the same effect. But see also the judgment of Jessel., M.R, in *Taylor* v. *Corporation of Oldham* (1876), 4 Ch. D. 395.

A cul-de-sac, if "public," may of course be a public street. *Souch* v. *East London Railway Company* (1873), L. R. 16 Eq. 108, and note the use of the word "thoroughfare" in the definition Electric Lighting Act, sec. 32.

(*c*) These words do not impose on the undertakers the duty of using as little of their power as is needful. Whatever they are entitled to do, they may do. They must, however, do it *in such a way* as to do as little damage as possible (semble per Campbell, C.J., in *R.* v. *East and West India Docks*) (1853), 2 Ell. and B., 466; 22 L. J., Q. B. 380.

If in the course of breaking up a street a workman injure some person or property, two questions will arise : (1) Whose servant he is? and (2) Of what nature was his act? If his act was one of mere gratuitous misfeasance, out of the proper scope of his duty, he alone will be liable. If his act was one of negligence in the course of his employment, his employer will be liable, and who his employer is, is usually a question of fact tested generally by who selected him and can dismiss him. But besides the liability of his immediate employer, the persons who contracted with that employer will also be liable if they had directed that employer to do an act in itself unlawful, or if on the other hand, in the doing of it, some act which they owed to the public a duty to do or see done were by the workman left unperformed. The cases on these points will be found discussed in several works on torts and master and servant, so I will not pursue them further.

(*d*) This word includes buildings under the soil as well as above it. Hence no gas or electricity undertakers could break into cellars, even though they extend right under the road. *Thompson* v. *Sunderland Gas Company* (1877). 4 Ex. D. 429. (C. A.) In giving judgment, Bramwell, L.J., expressed an opinion that the Legislature had intended by sec. 6 of the Gasworks Clauses Act, 1847, to confer a gratuitous easement on the undertakers. And this "makes it almost certain that the Legislature did not mean that anything in which the landowner had a beneficial occupancy should be interferred with . . . . the soil of a public road where such mains are laid is of very little value to the owner . . . . therefore the Legislature enacted that this comparatively worthless ownership should be disregarded."

(*e*) *Consent.* This consent may be either expressed or implied. An instance of words in a deed which were held to give such consent is to be found in the case of *Selby* v. *the Crystal Palace Gas Company* (1862), 31 L. J., Ch. 595; 8 Jur. n.s. 830. A building estate containing some private occupation roads was divided between Price and Selby (the plaintiff's father). The latter took the roads, but by the deed (dated 1830, long prior to the Crystal Palace Gas Act, or even the Gasworks Clauses Act, 1847), consented that Price and all owners and occupiers for the time being of Price's part should have "as full and complete right of road . . . over such roads . . . as if the same were public roads." The defendant company had no power to lay pipes in the roads, and for the purposes of the argument it was conceded that they had never been dedicated to the public. On the request of some owners they broke up the roads. This the plaintiff, as freeholder, endeavoured to prevent, but; Held that the words above cited gave a right to the owners of houses to have the roads used as public roads for the laying of gas-pipes.

This consent would only extend when given as far as it was agreed. A consent once given to the placing of one pipe would enable the undertakers to replace, or repair, or alter that pipe as often as they pleased, but not to lay a new pipe. So in obtaining consent of owners, care must be taken to make the consent wide. Compare, for example, the narrow terms of this section with the sections of the Dover Gas Act, by which a company, who had once obtained the consent of the Mayor of Dover to the laying of pipes, were enabled to lay what pipes they liked, and from time to time to add as they pleased to them. *Dover Gaslight Company* v. *Mayor of Dover* (1855), 1 Jur. n.s. 812.

Notice to be served on persons having control, &c., before breaking up streets or opening drains.

VIII. Before the undertakers proceed to open or break up any street, bridge, sewer, drain, or tunnel, they shall give to the persons under whose control or management the same may be, or to their clerk, surveyor, or other officer, notice in writing of their intention to open or break up the same, not less than three clear days before beginning such work, except in cases of emergency arising from defects in any of the pipes or other works, and then so soon as is possible after the beginning of the work, or the necessity for the same shall have arisen.

For the usual provisions in orders as to breaking up of roads, see the Chelsea Provisional Order, clauses 12-18.

Streets or drains not to be broken up except under superintendence of persons having control of the same.

IX. No such street, bridge, sewer, drain, or tunnel shall, except in the cases of emergency aforesaid, be opened or broken up except under the superintendence of the persons having the control or management thereof, or of their officer, and according to such plan as shall be approved of by such persons or their officer, or in case of any difference respecting such plan, then according to such plan as shall be determined by two justices; and such justices may, on the application of the persons having the control or management of any such sewer or drain, or their officer, require the undertakers to make such temporary or other works as they may think necessary for guarding against any interruption of the drainage during the execution of any works which interfere with any such sewer or drain: Provided always, that if the persons having such control or management as aforesaid, and their officer, fail to attend at the time fixed for the opening of any such street, bridge, sewer, drain, or tunnel, after having had such notice of the undertakers' intention as aforesaid, or shall not propose any plan for breaking up or opening the same, or shall refuse or neglect to superintend the operation, the undertakers may perform the work specified in such notice without the superintendence of such persons or their officer.

If persons having the control, &c., fail to superintend, undertakers may perform the work without them.

Streets, &c. broken up to be reinstated without delay.

X. When the undertakers open or break up the road or pavement of any such street or bridge, or any sewer, drain, or tunnel, they shall with all convenient speed complete the work for which the same shall be broken up, and fill in the ground, and reinstate and make good the road or pavement, or the sewer, drain, or tunnel, so opened or broken up, and carry away the rubbish occasioned thereby, and shall at all times whilst any such road or pavement shall be so opened or broken up cause the same to be fenced and guarded, and shall cause a light sufficient for the warning of passengers to be set up and maintained against or near such road or pavement where the same shall be open or broken up, every night during which the same shall be continued open or broken up, and shall keep the road or pavement which has been so broken up in good repair for three months after replacing and making good the same, and for such further time, if any, not being more than twelve months in the whole, as the soil so broken up shall continue to subside.

Penalty for delay in reinstating streets, &c.

XI. If the undertakers open or break up any street or bridge, or any sewer, drain, or tunnel, without giving such notice as aforesaid, or in a manner different from that which shall have been approved of or determined as aforesaid, or without making such temporary or other works as aforesaid when so required, except

Laying of Pipes.
Sec. 11.

in the cases in which the undertakers are hereby authorised to perform such works without any superintendence or notice, or if the undertakers make any delay in completing any such work or in filling in the ground, or reinstating and making good the road or pavement, or the sewer, drain, or tunnel, so opened or broken up, or in carrying away the rubbish occasioned thereby, or if they neglect to cause the place where such road or pavement has been broken up to be fenced, guarded, and lighted, or neglect to keep the road or pavement in repair for the space of three months next after the same is made good, or such further time as aforesaid, they shall forfeit to the persons having the control or management of the street, bridge, sewer, drain, or tunnel in respect of which such default is made, a sum not exceeding five pounds for every such offence, and they shall forfeit an additional sum of five pounds for each day during which any such delay as aforesaid shall continue after they shall have received notice thereof.

In case of delay other parties may reinstate and recover the expenses.

XII. If any such delay or omission as aforesaid take place, the persons having the control or management of the street, bridge, sewer, drain, or tunnel in respect of which such delay or omission shall take place, may cause the work so delayed or omitted to be executed, and the expense of executing the same shall be repaid to such persons by the undertakers; and such expenses may be recovered in the same manner as damages are recoverable under this or the special Act.

Supply of Gas.

And with respect to the supply of gas, and the recovery of the rent to be paid for the same, be it enacted as follows:

Power of the company to contract for lighting streets, &c.

XIII. The undertakers may from time to time enter into any contract with any person for lighting and supplying with gas any public or private building, or for providing any person with pipes, burners, meters, and lamps, and for the repair thereof; and may also from time to time enter into any contract with the commissioners, trustees, or other persons having the control of the streets within the limits of the special Act for lighting the same or any of them with gas, and for providing such commissioners, trustees, or persons with lamps, lamp posts, burners, and pipes for such purpose, and for the repairs thereof, in such manner and upon such terms as shall be agreed upon between the undertakers and the said commissioners, trustees, or other persons.

As to the supply of electricity, see also Electric Lighting Act, 1882, secs. 18, 19, 20.

Power to undertakers to let meters.

XIV. The undertakers may let for hire any meter for ascertaining the quantity of gas consumed or supplied, and any fittings for the gas, for such remuneration in money as shall be agreed upon between the undertakers and any person to whom the same may be so let, and such remuneration shall be recoverable in the same manner as the rents or sums due to the undertakers for gas; and such meters and fittings shall not be subject to distress, or to the landlord's hypothec for rent of the premises where the same may be used, nor to be taken in execution under any process of a court of law or equity, or any fiat or sequestration in bankruptcy against the person in whose possession the same may be.

Meters not liable to distraint for rent, &c.

Compare Electric Lighting Act, 1882, sec. 25.

Undertakers may enter buildings for ascertaining quantities of gas consumed.

XV. The clerk, engineer, or other officer duly appointed for the purpose by the undertakers may, at all reasonable times, enter any building or place lighted with gas supplied by the undertakers in order to inspect the meters, fittings, and works for regulating the supply of gas, and for the purpose of ascertaining the quantity of gas consumed or supplied; and if any person hinder such officer as aforesaid from entering and making such inspection as aforesaid at any reasonable time, he shall for every such offence forfeit to the undertakers a sum not exceeding five pounds.

Compare Electric Lighting Act, 1882, sec. 24.

Recovery of rents due for gas.

XVI. If any person supplied with gas by virtue of this or the special Act neglect to pay the rent due for the same to the undertakers, the undertakers may stop the gas from entering the premises of such person, by cutting off the service-pipe, or by such means as the undertakers shall think fit, and recover the rent due from such person, if less than twenty pounds, together with the expense of cutting off the gas, and the costs of recovering the rent, in the same manner as any damages for the recovery of which no special provision is made are recoverable under this or the special Act, or if the rent so due amount to twenty pounds or upwards, the undertakers may recover the same, together with the expenses of cutting off the gas by action in any court of competent jurisdiction.

Amended by sec. 39, Gasworks Clauses Act, 1871 (34 and 35 Vict., c. 41). See also Electric Lighting Act, 1882, sec. 21 and sec. 24, and 10 Vict., c. 15, sec. 40.

XVII. In all cases in which the undertakers are authorised to

Supply of Gas.

Sec. 17.

Power to take away pipes, &c., when supply of gas discontinued.

cut off and take away the supply of gas from any house or building or premises, under the provisions of this or the special Act, the undertakers, their agents or workmen, after giving twenty-four hours previous notice to the occupier, may enter into any such house, building, or premises, between the hours of nine in the forenoon and four in the afternoon, and remove and carry away any pipe, meter, fittings, or other works the property of the undertakers.

And with respect to waste or misuse of the gas, or injury to the pipes and other works, it is enacted as follows:

Undue Use of Gas.

Penalty for fraudulently using the gas of the undertakers.

XVIII. Every person who shall lay or cause to be laid any pipe to communicate with any pipe belonging to the undertakers without their consent, or shall fraudulently injure any such meter as aforesaid, or who, in case the gas supplied by the undertakers is not ascertained by meter, shall use any burner (other than such as has been provided or approved of by the undertakers or) (*a*) of larger dimensions than he has contracted to pay for, or shall keep the lights burning for a longer time than he has contracted to pay for, or who shall otherwise improperly use or burn such gas (*b*) or shall supply any other person with any part of the gas supplied to him by the undertakers, shall forfeit to the undertakers the sum of five pounds for every such offence, and also the sum of forty shillings for every day such pipe shall so remain, or such works or burner shall be so used, or such excess be so committed or continued, or such supply furnished; and the undertakers may take off the gas from the house and premises of the person so offending, notwithstanding any contract which may have been previously entered into.

This section is further amended by sec. 38 of the Gasworks Clauses Act, 1871 (34 and 35 Vict., c. 41), and also by secs. 22 and 23 of the Electric Lighting Act, 1882. See notes to same.

(*a*.) These words to be omitted in applying the Act to electric lighting. Electric Lighting Act, 1882, sec. 12. See also sec. 18.

(*b*.) *Fowler* v. *Newbigging*, 23 J. P. 52.

Penalty for wilfully damaging pipes.

XIX. Every person who shall wilfully remove, destroy, or damage any pipe, pillar, post, plug, lamp, or other work of the undertakers for supplying gas, or who shall wilfully extinguish any of the public lamps or lights, or waste or improperly use (*a*) any of the gas supplied by the undertakers, shall for each such offence forfeit to the undertakers any sum not exceeding five pounds, in addition to the amount of the damage done.

See note to last section, and to secs. 22 and 23, Electric Lighting Act, 1882.

(*a.*) See note (*b*) to last section.

Satisfaction for accidentally damaging pipes.

XX. Every person who shall carelessly or accidentally break, throw down, or damage any pipe, pillar, or lamp belonging to the undertakers, or under their control, shall pay such sum of money by way of satisfaction to the undertakers for the damage done, not exceeding five pounds, as any two justices or the sheriff shall think reasonable.

See note to secs. 22 and 23, Electric Lighting Act, 1882.

Recovery of Damages and Penalties.

And with respect to the recovery of damages not specially provided for, and of penalties, and to the determination of any other matter referred to justices or to the sheriff, be it enacted as follows:

See Electric Lighting Act, 1882, sec. 12, last paragraph.

The Railways Clauses Consolidation Act, 1845, as to damages, &c., to be incorporated with this and the special Act.

XL. If the gasworks be in *England* or *Ireland*, the clauses of the Railways Clauses Consolidation Act, 1845, with respect to the recovery of damages not specially provided for, and of penalties, and to the determination of any other matter referred to Justices shall be incorporated with this and the special Act; and if the gas works be in *Scotland*, the clauses of the Railways Clauses Consolidation Act (*Scotland*), 1845, with respect to the recovery of damages not specially provided for, and to the determination of any other matter referred to the sheriff or to justices, shall be incorporated with this and the special Act, and such clauses shall apply to the gasworks and to the undertakers respectively, and shall be construed as if the word "undertakers" had been inserted therein instead of the word "Company."

See note to Electric Lighting Act, 1882, sec. 21.

The succeeding sections 41-44 deal with the application of the moneys recovered as penalties, and with perjury.

GASWORKS CLAUSES ACT, 1871.

34 & 35 Vict. Cap. XLI.

An ACT to amend the Gasworks Clauses Act, 1847.
[13*th July*, 1871.

By sec. 12 of the E. L. Act, 1882; secs. 38-42, and secs. 45 and 46 of this Act are incorporated. For "gas" is to be read "electricity," &c., as provided in sec. 12 of the E. L. Act, 1882.

Penalty for injuring meters.

38. Every person who wilfully, fraudulently, or by culpable negligence injures or suffers to be injured any pipes, meter, or fittings belonging to the undertakers, or alters the index to any meter, or prevents any meter from duly registering the quantity of gas supplied, or fraudulently abstracts, consumes, or uses gas of the undertakers, shall (without prejudice to any other right or remedy for the protection of the undertakers or the punishment of the offender) for every such offence forfeit and pay to the undertakers a sum not exceeding five pounds, and the undertakers may in addition thereto recover the amount of any damage by them sustained; and in any case in which any person has wilfully or fraudulently injured or suffered to be injured any pipes, meter, or fittings belonging to the undertakers, or altered the index to any meter, or prevented any meter from duly registering the quantity of gas supplied, the undertakers may also, until the matter complained of has been remedied, but no longer, discontinue the supply of gas to the person so offending (notwithstanding any contract previously existing); and the existence of artificial means for causing such alteration or prevention, or for abstracting, consuming, or using gas of the undertakers, when such meter is under the custody or control of the consumer, shall be primâ facie evidence that such alteration, prevention, abstraction, or consumption, as the case may be, has been fraudulently, knowingly, and wilfully caused by the consumer using such meter.

See sec. 18 of the Gasworks Clauses Act, 1847, (10 Vict. c. 15) and E. L. Act, secs. 22 and 23.

Recovery of Gas Rents.

Incoming tenants not liable to pay arrears of gas rents, &c.

39. In case any consumer of gas supplied by the undertakers leaves the premises where such gas has been supplied to him without paying the gas rent or meter rent due from him, the undertakers shall not be entitled to require from the next tenant of such premises the payment of the arrears left unpaid by the former tenant, unless such incoming tenant has undertaken with the former tenant to pay or exonerate him from the payment of such arrears.

This section amends sec. 16 of the Gasworks Clauses Act, 1847 (10 Vict. c. 15), see also E. L. Act, 1882, secs. 21 and 24.

Under this section, *Gaslight & Coke Co.* v. *Mead* (1876), 45 L. J. M. C. 71, decides that words very similar to these do not show that the incoming tenant is liable, even where he has contracted with the outgoing tenant; they only show cases in which he is not liable.

Recovery of rents, &c.

40. If any person supplied with gas or with any gas meter or fittings by the undertakers neglects to pay to the undertakers the rent due for such gas or the rent or money due to the undertakers for the hire or fixing of such meter, or any expenses lawfully incurred by the undertakers in cutting off the gas from the premises of such person, the undertakers may recover the sum so due (in like manner as a penalty under this Act)* summarily as a civil debt.

Compare sec. 16 Gasworks Clauses Act, 1847 (10 Vict. c. 15) and E. L. Act, 1882, sec. 21. See also Summary Jurisdiction Act, 1879, 42 and 43 Vict. c. 49, secs. 6, 35.

Recovery of sums due to undertakers.

41. Whenever any person neglects to pay any rent or sum due and payable by him to the undertakers, the undertakers may recover the same, with full costs of suit, in any court of competent jurisdiction, and the remedy of the undertakers under this enactment shall be in addition to their other remedies for the recovery of such rent or sum.

Legal Proceedings.

Contents of summons or warrant.

42. Any summons or warrant issued for any of the purposes of this Act may contain, in the body thereof or in a schedule thereto, several names and several sums.

Service of notices by undertakers.

45. Every notice which the undertakers are by this Act required to serve upon any person shall be served by being delivered to the person for whom it is intended, or by being left at his usual or last known place of abode, or sent by post addressed

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* See E. L. Act, 1882, sec. 12, last paragraph.

Sec. 46.

to such persons, or if such person or his address be not known to the undertakers, and cannot after due inquiry be found or ascertained, then by being affixed for three days to some conspicuous part of the premises to which such notice relates.

Liability to gas rent not to disqualify justices from acting.

46. No justice or judge of any county court or quarter sessions shall be disqualified from acting in the execution of this Act by reason of his being liable to the payment of any gas rent or other charge under this Act.

THE
BOARD OF TRADE ARBITRATIONS ACT, 1874.

37 & 38 VICT. CAP. 40.

Applied to the Electric Lighting by sec. 28 of Electric Lighting Act, 1882.

A.D. 1874.

An ACT to amend the powers of the Board of Trade with respect to inquiries, arbitrations, appointments, and other matters under special Acts, and to amend the Regulation of Railways Act, 1873, so far as regards the reference of differences to the railway commissioners in lieu of arbitrators.
[*30th July* 1874.

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons in this present Parliament assembled, and by the authority of the same, as follows:

Preliminary.

Short title.

1. This Act may be cited as the Board of Trade Arbitrations, &c., Act, 1874.

PART I.

Board of Trade Inquiries. &c.

Power of Board of Trade as to inquiry.

2. Where, under the provisions of any special Act, passed either before or after the passing of this Act, the Board of Trade are required or authorised to sanction, approve, confirm, or determine any appointment, matter, or thing, or to make any order or to do any other act or thing for the purposes of such special Act, the Board of Trade may make such inquiry as they may think necessary for the purpose of enabling them to comply with such requisition or exercise such authority.

Where an inquiry is held by the Board of Trade for the

Board of Trade Inquiries, &c. Sec. 2.

purposes of this section, or in pursuance of any general or special Act passed either before or after the passing of this Act, directing or authorising them to hold any inquiry, the Board of Trade may hold such inquiry by any person or persons duly authorised in that behalf by an order of the Board of Trade, and such inquiry if so held shall be deemed to be duly held.

Expenses connected with arbitration, sanction, &c.

3. Where application is made in pursuance of any special Act passed either before or after the passing of this Act, to the Board of Trade to be arbitrators, or to appoint any arbitrator, referee, engineer or other person, or to hold any inquiry, or to sanction, approve, confirm, or determine, any appointment, matter, or thing, or to make any order, or to do any other act or thing for the purposes of such special Act, all expenses incurred by the Board of Trade in relation to such application and the proceedings consequent thereon, shall, to such amount as the Board of Trade may certify by their order to be due, be defrayed by the parties to such application, and (subject to any provision contained in the said special Act) shall be defrayed by such of the parties as the Board of Trade may by order direct, or if so directed by an order of the Board of Trade, shall be paid as costs of the arbitration or reference.

The Board of Trade may, if they think fit, on or at any time after the making of the application, by order require the parties to the application, or any of them, to pay to the Board of Trade such sum as the Board of Trade think requisite for or on account of those expenses, or to give security to the satisfaction of the Board of Trade for the payment of those expenses on demand, and if such payment or security is not made or given, may refuse to act in pursuance of the application.

All expenses directed by an order of the Board of Trade or an award in pursuance of this section to be paid, may be recovered in any court of competent jurisdiction as a debt, and if payable to the Board of Trade, as a debt to the Crown, and an order of the Board of Trade shall be conclusive evidence of the amount of such expenses.

Meaning of "special Act."

4. In this part of this Act the term "special Act" means a local or local and personal Act, or an Act of a local and personal nature, and includes a provisional order of the Board of Trade confirmed by Act of Parliament, and a certificate granted by the Board of Trade under the Railways Construction Facilities Act, 1864.

Order of Board of Trade may be in writing.

An order of the Board of Trade for the purposes of this part of this Act, or of any such special Act as is referred to in this part of this Act, may be made by writing under the hand of the President or of one of the secretaries of the Board.

Repeal of 35 and 36 Vict. c. 18.

5. The Act of the session of the thirty-fifth and thirty-sixth years of the reign of Her present Majesty, chapter eighteen, intituled "An Act for regulating Inquiries by the Board of Trade" is hereby repealed, without prejudice to anything done or suffered under that Act.

PART II.

Reference to Railway Commissioners.

Power of Board of Trade to appoint Railway Commissioners to be arbitrators or umpire.

6. Where any difference to which a railway company or canal company is a party is required or authorised under the provisions of any general or special Act passed either before or after the passing of this Act, to be referred to the arbitration of or to be determined or settled by the Board of Trade, or some person or persons appointed by the Board of Trade, the Board of Trade may, if they think fit, by order in writing under the hand of the President or one of the Secretaries of the Board, refer the matter for the decision of the Railway Commissioners, and appoint them arbitrators or umpire, as the case may be, and thereupon the Commissioners for the time being shall have the same powers as if the matter had been referred to their decision in pursuance of the Regulation of Railways Act, 1873, and also any further powers which the Board of Trade, or an arbitrator or arbitrators, or umpire, appointed by the Board of Trade, would have had for the purpose of the arbitration, if the difference had not been referred to the Commissioners: Provided always, that this section shall not apply to any case in which application is made to the Board of Trade for the appointment of an umpire under the twenty-eighth section of "The Lands Clauses Consolidation Act, 1845."

Declaration as to powers of Commissioners in arbitrations.

7. Where any difference is referred for the decision of the Commissioners in pursuance of the Regulation of Railways Act, 1873, as amended by this part of this Act, the Commissioners shall have the same power by their decision of rescinding, varying, or adding to any award or other decision previously made by any arbitrator or arbitrators (including therein the Board of Trade) with reference to the same subject-matter as any arbitrator or arbitrators would have had if the difference had been referred to him or them.

Duration, &c. of part of Act, and construction with 36 and 37 Vict. c. 48.

8. This part of this Act shall be construed as one with the Regulation of Railways Act, 1873, and shall continue in force for the same time as that Act and no longer, but the expiration of

this part of this Act shall not affect the validity of anything done before such expiration. Board of Trade Inquiries, &c.

The Regulation of Railways Act, 1873, together with this part of this Act, may be cited as the Regulation of Railways Act, 1873 and 1874.

TELEGRAPH ACT, 1878.

41 & 42 VICT. Cap. 76.

Before this general Act, it had been customary to insert in all local Acts, restrictions in favour of the Postmaster-General. To obviate this inconvenience, the Telegraph Act, 1878, was passed, which is partly incorporated in sec. 26 of the E. L. Act, 1882, which provides, that any alterations in the telegraph lines of the Postmaster-General, are to be subject to the Telegraph Act, 1878.

The incorporated sections are 2 and 7-12, which provide for the manner in which undertakers are to proceed when they wish to do any work involving any alteration in a telegraph line belonging to the Postmaster-General. These provisions are further modified by the said section 26 of the E. L. Act, 1882, to which they are subject, see E. L. Act, sec. 26.

41 & 42 VICT. Cap. 76.

An ACT to make further Provision respecting the Post Office Telegraphs.
[16*th August*, 1878.

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1. This Act may be cited as the Telegraph Act, 1878. Short title.

2. In the construction of this Act, unless there is something inconsistent in the context, words and expressions shall have the same meanings as in the Telegraph Act, 1863, and in addition thereto— Definitions.

The expressions "street" and "public road" shall respectively include any highway:

The expression "Act of Parliament" means any Act of Parliament whether public general, local and personal, or private, and includes the order confirmed by any such Act, and includes a certificate granted by the Board of Trade under the Railways Construction Facilities Act, 1864:

The expression "Telegraph Acts" includes the Telegraph

Telegraph Act, 1878.

26 and 27 Vict. c. 112.
29 and 30 Vict. c. 3.
31 and 32 Vict. c. 110.
32 and 33 Vict. c. 73.
33 and 34 Vict. c. 88.

Act, 1863, the Telegraph Act Amendment Act 1866, the Telegraph Act, 1868, the Telegraph Act, 1869, the Telegraph Act, 1870, this Act and any Acts or parts of Acts incorporated with such Acts or referred to therein, any or either of them, and such several Acts may be cited together as the Telegraph Acts, 1863 to 1878 :

The expression "undertaking" means the works or undertaking of whatever nature the execution of which is authorised by an Act of Parliament as above defined :

The expression "undertakers" means the parties, whether company, commissioners, trustees, corporations, or private persons, empowered by an Act of Parliament as above defined to execute an undertaking, and any lessee or tenant thereof :

The expression "agents" includes contractors, and also the officers, engineers, workmen, or servants, as well of the Postmaster-General, undertakers, bodies, or persons, as of his or their contractors :

The expression "telegraphic line" means telegraphs, posts, and any work (within the meaning of the Telegraph Act, 1863), and also any cables, apparatus, pneumatic or other tube, pipe, or thing whatsoever used for the purpose of transmitting telegraphic messages or maintaining telegraphic communication, and includes any portion of a telegraphic line as defined by this Act :

The expressions "alteration," "alter," and "altering" in respect of a telegraphic line, include the substitution of any new line or portion of a line, either in the same place or in some other place, also any removal of or other dealing with any telegraphic line or any part of such line.

* * * * *

Provision as to work done in pursuance of special Acts of Parliament which involves alteration in telegraphic line.

7. Where any work proposed to be done in the execution of an undertaking authorised by an Act of Parliament involves or is likely to involve an alteration either temporarily or permanently in any telegraphic line of the Postmaster-General, and provision is not otherwise made by enactment, agreement, or otherwise with respect to such alteration or to giving notice to the Postmaster-General thereof or to the expenses of or incidental thereto, the following enactments shall apply :

(1.) The undertakers or their agents shall give to the Postmaster-General not less than seven nor more than fourteen days previous notice of the time and place at which the

Telegraph Act, 1878.

work will be begun and the nature of the alteration required:

But see E. L. Act, 1882, sec. 26.

(2.) Before the expiration of seven days after the notice is given the Postmaster-General may give the undertakers or their agents a counter-notice either stating his intention himself to make, or requiring the undertakers to make under the supervision and to the satisfaction of himself or his agents, such alteration in the telegraphic line as he deems necessary or expedient to be made in consequence of the proposed work:

(3.) If the Postmaster-General by his counter-notice states that it is his intention himself to make such alteration, it shall be lawful for such Postmaster-General by himself or his agents to make the same, and the undertakers or their agents shall pay to the Postmaster-General all the expenses incurred by him of and incidental thereto, and the amount of any loss or damage sustained by him in consequence thereof:

(4.) If the Postmaster-General by his counter-notice requires the undertakers or their agents to make such alteration, the undertakers or their agents shall, at their own expense, make the same under the supervision and to the reasonable satisfaction of the Postmaster-General or his agents, and the said undertakers shall pay to the Postmaster-General all the expenses incurred by him of and incidental to such supervision, also the amount of any loss or damage sustained by him in consequence of the alteration:

(5.) If the Postmaster-General fails to give a counter-notice, or if having undertaken himself to make the alteration he or his agents should fail to make within a reasonable time the alteration, the undertakers or their agents may themselves make the alteration to the reasonable satisfaction of the Postmaster-General or his agents:

See E. L. Act, sec. 26, paragraph 4.

(6.) If any undertakers or their agents fail to serve on the Postmaster-General such notice as is required by this section with respect to any work, or begin to do the work specified in a notice served under this section before the expiration of seven days after the notice is given, they shall be liable to pay a fine not exceeding ten pounds for every day during which they continue such work without the sanction in writing of the Postmaster-General, and the Postmaster-General may at the expense of the undertakers remove such work:

See E. L. Act, sec. 26, paragraph 4.

(7.) If any undertakers or their agents fail to comply with the reasonable requirements of the Postmaster-General or his agents under this section, they shall be liable to a fine not exceeding ten pounds for every day during which such failure continues, or if the telegraphic communication is interrupted, not exceeding fifty pounds for every day on which such interruption continues:

See E. L. Act, sec. 26, paragraph 5.

(8.) Provided that nothing in this section shall subject any undertakers or their agents to a fine for omitting to comply with any requirements of the Postmaster-General or his agents, or for executing without previous notice any work if they satisfy the court having cognizance of the case that any such requirement was unreasonable or that the immediate execution of the work was required to avoid an accident, or otherwise was a work of emergency, and that they forthwith served on the postmaster or sub-postmaster of the postal telegraph office nearest to the place where the work was done a notice of the execution thereof, stating the reason for executing the same without previous notice:

And where under section eight of the Telegraph Act, 1863, any body to or by whom any such pipe as in that section mentioned belongs or is used require that the position of any telegraphic line of the Postmaster-General or any part thereof should be altered, the enactments of the present section shall apply, and for such purposes any such body shall be deemed to be "undertakers."

Compensation and fine for injury to telegraphic line of the Postmaster-General and for interruption to telegraphic communication.

8. Where any undertakers, body, or person, by themselves or by their agents, destroy or injure any telegraphic line of the Postmaster-General, such undertakers, body, or person shall not only be liable to pay to the Postmaster-General such expenses (if any) as he may incur in making good the said destruction or injury, but also, if the telegraphic communication is carelessly or wilfully interrupted, shall be liable to a fine not exceeding twenty pounds per day for every day during which such interruption continues.

Where the undertakers, body, or person liable to pay such daily fine as aforesaid to the Postmaster-General are not authorised to execute such works as may be required for remedying the interruption, the interruption shall be deemed to continue either for the time during which it actually continues or for such less time as in the opinion of the court having cognizance of the case would have been sufficient for remedying the interruption by the Postmaster-General.

The Postmaster-General may, instead of taking proceedings for the recovery of such daily fine as aforesaid, proceed for the recovery of a fine not exceeding fifty pounds, to which the undertakers, body, or person shall be liable on summary conviction.

An act done to a telegraphic line in the course of work undertaken by any undertakers, body, or person in the legal exercise of a right shall not be deemed to be wilful destruction of or injury to such telegraphic line, if due notice of the intended exercise of such right has been given to the Postmaster-General, that is to say, the notice required to be given in pursuance of any Act of Parliament or agreement, or where there is no Act of Parliament or agreement requiring such notice, fourteen clear days notice.

This section shall be deemed to be in addition to and not in derogation of any other power or means which the Postmaster-General may have of recovering damages in respect of any such destruction or injury as in this section mentioned under any other Act of Parliament or at common law or otherwise, provided that he shall not proceed under this Act and under any other Act or law in respect of the same destruction or injury.

Penalty for obstruction.

9. Where any undertakers, body, or person or their agents obstruct the Postmaster-General or his agents in placing, maintaining, altering, examining, or repairing any telegraphic line in pursuance of this Act, or of any consent given in pursuance of this Act, or in supervising or directing any alteration in any telegraphic line made by any undertakers or their agents in pursuance of this Act, such undertakers, bodies, or persons and agents respectively shall for every act of obstruction be liable to a fine not exceeding ten pounds, or in case such obstruction continues, ten pounds for every day during which the same continues.

Prosecution of offences.

10. All fines and penalties under any of the Telegraph Acts may be recovered by the Postmaster-General in manner provided by the Summary Jurisdiction Acts before a court of summary jurisdiction, and for the purposes of this Act—

(1.) The expression "Summary Jurisdiction Acts" means—
as respects England, the Act of the session of the eleventh and twelfth years of the reign of Her present Majesty, chapter forty-three, intituled "An Act to facilitate the "performance of the duties of justices of the peace out "of sessions within England and Wales with respect to

" summary convictions and orders," and any Act passed or to be passed amending the same; and

27 and 28 Vict. c. 53.

as respect Scotland, the Summary Procedure Act, 1864, and any Act passed or to be passed amending the same; and

as respects Ireland, within the police district of Dublin metropolis, the Acts regulating the powers and duties of justices of the peace for such district, or of the police of that district, and elsewhere in Ireland the Petty Sessions (Ireland) Act, 1851, and any Act passed or to be passed amending the said Acts, or any of them; and

(2.) The expression " court of summary jurisdiction " means—

as respects England, any justice of the peace or other magistrate or officer to whom jurisdiction is given by the Summary Jurisdiction Acts, so, however, that any case arising under any of the Telegraph Acts shall be heard and determined either by two or more justices of the peace in petty sessions sitting at a court or other place appointed for holding petty sessions, or by some magistrate or officer sitting alone or with others at some court or other place appointed for the administration of justice, and for the time being empowered by law to do alone any act authorised to be done by more than one justice of the peace; and

as respects Scotland, means any sheriff or sheriff substitute and

as respects Ireland, means any justice or justices or other magistrate, by whatever name called, having jurisdiction under the Summary Jurisdiction Acts.

All fines and penalties recovered in pursuance of any of the Telegraph Acts shall be paid into the exchequer.

Provision as to Postmaster-General.

11. In the Telegraph Acts the expression "Postmaster-General" means her Majesty's Postmaster-General for the time being.

Any legal proceeding may be instituted by the Postmaster-General for any of the purposes of any of the Telegraph Acts in the name of her Majesty's Postmaster-General for the time being, and shall not abate or be discontinued by reason of any change in the person who is Postmaster-General, but may be carried on as if her Majesty's Postmaster-General for the time being were a body corporate; and where any sum is due or payable to the Postmaster-General under any of the Telegraph Acts, or any contract, agreement, or regulations made in pursuance or for any of the purposes of those Acts or any of them, the Postmaster-General may recover the same as a debt in any court and in any manner in which it might be recovered if it were a debt due to a private person.

Printing, authentication, and service of notices and other documents.

See E.L. Act, 1882, sec. 26, para. 2.

12. A notice under this Act may be in writing or print, or partly in writing and partly in print.

Any notice, appointment, direction, or document given, issued, or made for the purposes of this Act by the Postmaster-General shall be sufficiently authenticated if purporting to be signed by a secretary or assistant-secretary of the Post-Office, or by a superintending engineer of the Postmaster-General, or by an officer appointed for the purpose by the Postmaster-General, and when so authenticated shall be deemed to be given, issued, or made by the Postmaster-General.

Where a notice is given by any undertakers, body, or person, the notice shall be sufficiently authenticated if purporting to be signed by the chairman, secretary, clerk, or other officer of such undertakers, body, or person.

A notice required to be given under this Act to the Postmaster-General may be given by leaving the same at or by forwarding the same by post to the General Post-Office in a letter addressed to the Postmaster-General or to the secretary of the Post-Office, or to an assistant secretary of the Post-Office, or by delivering the same to or forwarding the same by post in a letter addressed to the superintending engineer of the Postmaster-General for the district in which is the work, telegraphic line, or other matter referred to in the notice and addressed to him at his office or usual place of abode.

A notice required to be given under this Act to any undertakers or body may be given by leaving the same at, or by forwarding the same by post to the office, or where there is more than one office, the principal office of such undertakers or body in a letter addressed to such undertakers or body, or to their chairman, secretary, clerk, or other officer.

A notice required to be given under this Act to any person may be given by delivering the same to such person, or by leaving the same at, or forwarding the same by post in a letter addressed to such person, at his usual or last-known place of abode.

Where a notice is forwarded by post it shall be deemed to have been given at the time when the letter containing the same would be delivered in the ordinary course of post, and in proving the giving thereof it shall be sufficient to prove that the same was properly addressed and put into the post.

The expression "notice" in this section shall be deemed to include a counter-notice.

Land Clauses Act.

LANDS CLAUSES ACTS.

(See sec. 12 of E. L. Act of 1882.)

The Lands Clauses Acts, incorporated with the Electric Lighting Act, 1882, (secs. 12, 32 and 36), are

8 and 9 Victoria c. 18 (1845) (England and Ireland), secs. 1-15 and 69 to the end, and note that the meaning of "lands" is here extended by sec. 12 of the E. L. Act, to include any easement in lands.

8 and 9 Victoria c. 19. (1845) (Scotland), which Act is almost identical with the corresponding Act for England.

23 and 24 Victoria c. 106, (1860) (Great Britain and Ireland), which provides for payments for land by way of rent charge and annual duties, instead of gross sums.

32 and 33 Vict. c. 18, (1869) (England and Ireland), which provides for the settlement of disputed compensation by arbitration.

I have not discussed the details of these Acts, for want of space, but there are several exhaustive treatises on the subject.

Public Health Acts.

PUBLIC HEALTH ACTS.

THE PUBLIC HEALTH ACT, 1875 (ENGLAND).

(38 & 39 VICT. Cap. 55.)

This Act consolidates and amends the Acts establishing those urban and rural sanitary authorities who are to provide electricity or superintend its supply.

The sections chiefly applicable are as follows :—(See E. L. Act, 1882, secs. 7, 8, 9, 31 and schedule).

Sections 4 and 5, 6, 9, which define and designate the local, urban and rural sanitary authorities, and their districts.

Secs. 161-163, which deal with the general powers of urban authorities as to lighting.

Secs. 207-212 and 218-228, which empower the urban authorities to levy borough and general district rates.

229-231, which deal with the special rates to be levied by rural authorities.

233-234, which confer borrowing powers on the urban and rural sanitary authorities.

245-250, which prescribe the mode of audit of accounts.

THE PUBLIC HEALTH ACT (SCOTLAND) 1867.

(30 & 31 VICT., Cap. 101.)

30 and 31 Vict. c. 101. (1867) has been amended in details by 34 and 35 Vict. c. 38, and 38 and 39 Vict. c. 74.

Public Health Act.

In Scotland in towns the Electric Lighting authority will in general be the Sanitary Authority, in the country it will be the Road Authority.

PUBLIC HEALTH ACT (IRELAND), 1878.

(41 & 42 VICT. Cap. 52.)

This Act, as regards Ireland, is to be taken as incorporated in exactly the same manner as the Public Health Act (1875) England is incorporated. (See Electric Lighting Act schedule.) The Acts are somewhat similar. Page 48.

The following are the corresponding sections.

	P. H. Act (Ireland).
Definitions of Sanitary Authority	3
,, ,, Urban	4
,, ,, Rural	6

(The corresponding sections for England are 5, 6, 9, of Public Health Act, 1875, 38 & 39 Vict. c. 55).

	P. H. Act (Ireland).
Rates upon which expenses are to be charged as provided in the schedule	226 227 228 232

(The corresponding sections for England are Part IV. 207-212 of Public Health Act, 1875, 38 & 39 Vict. c. 55).

Special Expenses... ... ... 232, 233

(The corresponding sections for England are 229, 230 of Public Health Act, 1875, 38 & 39 Vict. c. 55).

As to borrowing 237, 238, 240, 241, 242, 243

(The corresponding sections for England are 233, 234, 236, 237, 238, 239 of Public Health Act, 1875, 38 & 39 Vict. c. 55).

METROPOLIS MANAGEMENT ACT, 1855.

(18 & 19 VICT. Cap. 120.)

Metropolis Management Act, 1855.

This Act is referred to in the schedule of the Electric Lighting Act, 1882, as regulating the rating and borrowing powers of those parishes and districts within the Metropolis as are not under the control of the Corporation of London or the Metropolitan Board of Works. Schedules A. and B. contain the lists of such parishes and districts. The sections which are most important as regards the Electric Lighting Act are as follow :—

Metropolis Management Act, 1855.

Secs. 1-30. Definition of Vestries, which, under the Electric Lighting Act, form the local authorities for the Metropolitan parishes.

Secs. 31-42. Definition of the District Boards which form the local authority for electric lighting for the Metropolitan districts.

Secs. 43-53. Constitution of the Metropolitan Board of Works.

Sec. 90. Transference of lighting powers to the Vestries and District Boards.

Secs. 110-114. No streets to be broken up by any one, except under the superintendence of the Vestries and District Boards.

Sec. 130. Duty of Vestries and District Boards properly to light the streets with gas or otherwise.

Secs. 149, 151, 152. Power to Vestries and District Boards to make contracts and buy lands by agreement under the Lands Clauses Act, 1845.

Secs. 158-160. Provisions for defraying expenses.

Sec. 161. The lighting rate to be a distinct rate.

Sec. 165. Exemptions from lighting rate.

Secs. 183-191. Borrowing powers.

Sec. 195. Audit of accounts.

This Act is amended by 19 & 20 Vict. c. 112, and 21 & 22 Vict. c. 104, and 25 & 26 Vict. c. 102.

Local Loans Act, 1875.

LOCAL LOANS ACT, 1875.

(38 & 39 Vict. Cap. 83.)

By sec. 8 of the Electric Lighting Act, 1882, local authority of districts to which the Local Loans Act applies, and which have got provisional orders, licenses, &c., may borrow money as in that Act provided, but subject to conditions to be prescribed by the authority in the fifth column of the Schedule to the Electric Lighting Act, 1882.

OFFICIAL DOCUMENTS EMANATING FROM THE BOARD OF TRADE, IN RELATION TO PROVISIONAL ORDERS AND LICENSES UNDER THE ELECTRIC LIGHTING ACT, 1882.

The October Rules, 1882.

Rules made by the Board of Trade with respect to Applications for Licenses, Provisional Orders, &c.

These Rules were made in August, 1882, *and slightly modified in October,* 1882. *They are made under the powers contained in sec.* 5 *of the Electric Lighting Act,* 1882, *and are to be judicially noticed. A sketch of the procedure is given in the introduction, sec.* 3.

Page 19. Page 6.

Rule I.—No application for a license or for the renewal of a license can be entertained unless proof of the consent of the local authority to such application is given to the Board of Trade.

E. L. Act sec. 3 (1).

Rule II.—When applications for provisional orders authorising the supply of electricity within the district of any local authority are received by the Board of Trade from such local authority, and also from any other authority, company, or person, the Board of Trade will give a preference to the application of the local authority of the district in every case where, in the opinion of the Board of Trade, no special circumstances exist which render such a preference inexpedient.

Application and Deposit.

Rule III.—Every application for a license or provisional order must be made by a memorial signed by or on behalf of the applicants, headed with a short title descriptive of the proposed undertaking (corresponding with that at the head of the advertisement hereinafter mentioned), addressed to the Board of Trade, and praying for a license or provisional order. With the memorial must be deposited six copies of the license or order, as proposed by the applicants, with the schedule or schedules (if any) referred to therein.

Page 7.

Rule IV.—The deposited copies of the proposed license or order must be in print. They must be printed on one side only of the page of paper, so as to leave the back of the page blank, and each schedule annexed must begin a new page.

The names and addresses of the parliamentary agents or solicitors for the license or order must be printed on the outside of the draft.

There must be a notice at the end of the draft, stating that objections are to be made by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it "Electric Lighting Act," and that this letter is to be sent to the Board of Trade within two months from the date of the newspaper containing the first advertisement of the application.

The draft must contain, amongst other things—

. L. Act, sec. 3 (7).

1. Address and description of the applicants.

E. L. Act, secs. 3, 4, 6 (a).

2. A description of the proposed area of supply.

E. L. Act, sec. 3 (3, 4).

3. A statement of the purposes for which a supply is to be given, viz., any or all of the public or private purposes specified in section 3 of the Act.
4. A general description of the proposed works.

E. L. Act, sec. 13.

5. Provisions concerning the breaking up of streets not repairable by a local authority, and concerning interference with railways and tramways, where powers are sought to be obtained by the license or order for those purposes.

E. L. Act, sec. 6.

6. Conditions of supply, including price, nature and amount of supply, obligation to supply, &c.

E. L. Act, sec. 3 (2), sec. 4.

7. Period for which concession is sought.

E. L. Act, sec. 6 (c.)

8. Provisions for securing the safety of the consumer and of the public from injury by shock, fire, or otherwise.

E. L. Act, sec. 6 (*f.*)

9. Provisions for enforcing the performance by the undertakers of their duties in relation to the supply of electricity, and for the revocation of the license or order where the undertakers fail to perform such duties.

The applicants are also to deposit a sufficient number of such printed drafts at offices in London, and within the proposed area of supply to be specified in the advertisement, such copies to be there furnished to all persons applying for them, at a price of not more than one shilling each.

Rule V.—There must also be deposited with the memorial—

A published map of the district on a scale of not less than one inch to a mile, or if there is no published map, then the best map procurable showing the boundaries of the proposed area of supply, and the streets and other places in, over, or along which it is proposed to place any electric lines or other works.

A copy of the said map is also to be deposited for public inspection—

The October Rules, 1882.

In England or Ireland, in the office of the clerk of the peace for every county, riding, or division, and of the local authority of every district;

In Scotland in the office of the principal sheriff clerk, for every county, district or division, and of the local authority of every district

in which the proposed area of supply or any part thereof is situate.

Rule VI.—There must also be deposited with the memorial,—

1. A list of the local authorities in whose districts the area of supply is situate. Page 7.
2. A list of the streets not repairable by a local authority, and of the railways and tramways (if any) which the applicants propose to take powers to break up. E. L. Act, sec. 13. Page 27.
3. A list of the canals and navigable rivers (if any) which the undertakers will be empowered under the license or order to cross. E. L. Act, sec. 16.
4. A statement of the capital proposed to be expended and employed in connexion with the undertaking, and the mode in which such capital is to be provided. Page 8.
5. If the applicants are a company incorporated under the provisions of the Companies' Acts, a copy of the memorandum and articles of association.
6. A fee of 50*l.* by cheque payable to an "Assistant Secretary of the Board of Trade," to cover ordinary expenses. If in consequence of inquiries or otherwise, additional expense is incurred, the amount will be charged to the applicants and must be paid by them in addition to the ordinary fee.
7. Where the undertakers under any license, order, or special Act desire the consent of the Board of Trade to enable them to break up any street not repairable by a local authority, or any railway or tramway which they are not empowered to break up under such license, order, or special Act, the memorial must specially request such consent, and must describe accurately the street, railway, or tramway which they propose to acquire power to break up.

Rule VII.—Where the approval or consent of any local authority is required to any application for a license or order, such approval or consent must be given by a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, has been given in E. L. Act, sec. 3 (1-6). Pages 6, 12.

The October Rules, 1882.

the manner in which notices of meetings of such local authority are usually given, and the fact that such a resolution was duly passed, must be proved by furnishing a certificate signed by the secretary or clerk to such local authority embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

E. L. Act, sec. 4 (1).

Rule VIII.—In any case where a local authority, company, or person is required by the Act to give notice to the local authority of the district, "in such manner as the Board of Trade may direct or approve," such notice shall be given in writing, and shall be served, either by leaving the same at the offices of the said local authority on or before the appointed day, or by forwarding the same by post in a registered letter, so that the same would in ordinary course of post be delivered on or before the appointed day.

Page 6.

Procedure.

Rule IX.—Applicants for a license or provisional order must proceed as follows, *subject in the case of a license to the application having been previously entertained by the Board of Trade, vide Rule I.*:—

E. L. Act, sec. 3 (5). Page 16.

They shall publish notice by advertisement of their application, or in the case of a provisional order, of their intended application, and every such advertisement shall contain the following particulars:—

1. The objects of the application.
2. Address and description of applicants.
3. A general description of the nature of the proposed works.
4. A description of the proposed area of supply.
5. The names of the streets and other places in, over, or along which it is proposed to place any electric lines or other works.
6. A list of the streets not repairable by a local authority, and of the railways and tramways (if any) which the applicants propose to take powers by the license or order to break up.
7. A list of the canals and navigable rivers which the undertakers will be empowered under the license or order to cross.
8. An office in London, and another office within the proposed area of supply, at which printed copies of the draft license or order when applied for, and of the license or order when made, can be obtained at a price of not more than one shilling each.

The advertisement is to be headed with a short title, descriptive of the undertaking (corresponding with that at the head of the memorial), and it must state that every local or other public authority, company, or person desirous of making any representation to the Board of Trade, or of bringing before them any objection respecting the application, may do so by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it "Electric Lighting Act," within two months from the date of the newspaper containing the first advertisement.

The advertisement is to be inserted, once at least in each of two successive weeks in one and the same newspaper, published and circulating in the proposed area of supply, or in such other newspaper as the Board of Trade may direct; and once at least in the London, Edinburgh, or Dublin Gazette, accordingly as the proposed area of supply is situate in England, Scotland, or Ireland.

E. L. Act, sec. 3 (5). E. L. Act, sec. 5, B. of T. Arb. Act, secs. 2, 3.

Rule X.—In all cases of applications for a license, renewal of license, or provisional order, to which objection is made by any person locally interested, the Board of Trade will, if either the applicants or the objectors so desire, hold a local inquiry, of which due notice will be given.

Rule XI.—If any local or other public authority, company, or person desires to have any clauses or other amendments inserted in the license or order, they must deliver the same to the parliamentary agents or solicitors for the order, and also to the Board of Trade, on or before the time limited for bringing objections (two months,—see Rule IX. [8]).

E. L. Act, sec. 10.

Rule XII.—When a license or provisional order is ready, and before the same is delivered, the applicants must deposit at the office of the Board of Trade a description of the lands (if any) which they propose to purchase for the purposes of the license or provisional order, and must produce to the Board of Trade the contracts for the purchase of all such lands.

*No license or provisional order shall have any effect unless, and until, the applicants have deposited at the office of the Board of Trade a description of the lands (if any) which they propose to acquire for the purposes of the license or provisional order, and have produced to the Board of Trade contracts for the acquisition of all such lands.

**This amendment was made in April, 1883.*

Rule XIII.—When a license or provisional order has been made by the Board of Trade and delivered to the applicants, they shall forthwith deposit printed copies for public inspection in the offices specified in Rule V., and shall supply copies to all persons applying for the same, and shall further publish the same as the Board of Trade may direct.

The October Rules, 1882.

Special Provisions as to Provisional Orders.

Rule XIV.—In the case of provisional orders the following additional regulations must be observed:—

1. The advertisements must be inserted in *October* or *November*.

2. A copy of the advertisement and map must be deposited *on or before* the 30*th November* in the offices specified in Rule V., and at the Board of Trade.

3. The memorial must be lodged on or before 21*st December*.

4. The parliamentary agents or solicitors for the order must be prepared to prove compliance with the provisions of the Act and these rules by the 25th January, and all such proofs must be completed on or before the 25th February. Six days' notice will be given of the day and hour at which such agents or solicitors are to attend for the purpose at the Board of Trade, and printed forms of proof will accompany the notice. These forms should be filled up and brought with the requisite documents to the Board of Trade at the time fixed for receiving proof.

The Board of Trade,
October 1882.

T. H. Farrer,
Secretary.

Note.—*These Rules are with the following exceptions the same as those issued in August last.*

Rule V. The words "the lands which the applicants propose to take for the purposes of the license or order" have been omitted.

Rule IX. The wording of the first few lines of this Rule have been altered in order to make its meaning more clear.

(A) LICENSES.

License Proofs.

THE ELECTRIC LIGHTING ACT, 1882.

(Proofs required by the Board of Trade of due compliance, by the applicants, with the requirements. No special time for the lodging of these proofs has been prescribed, but they must be completed before the license is finally granted.)

BOARD OF TRADE, RAILWAY DEPARTMENT.

PROOFS

NOTE—1. *The particulars not applicable should be struck out and marked inapplicable.*
2. *Proof must be given in the manner specified in the margin.*
3. *Statutory declarations must be stamped.*

Required by the Board of Trade of Compliance with the Provisions of the Electric Lighting Act, 1882, and the Rules made by the Board of Trade under that Act. Page 13.

I. TITLE OF LICENSE.

II. NAME OF APPLICANTS.

Where Application is made by a Local Authority, not being the Local Authority of the whole of the area proposed to be supplied, Proof that the Application is made with the Consent of any or every other Local Authority having Jurisdiction within the area. E. L. Act, sec. 3 (7).

By affidavit or statutory declaration, with a list of the local authorities as an exhibit, and by production of the certificate or certificates.

III. will prove that the application for a license is made with the consent of every local authority (other than the applicants*) having jurisdiction within the area or any part of the area within which a E. L. Act. sec. 3 (1) and Rules 1 and 7.

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* For proof that application is made in pursuance of resolution passed by Local Authority applying *see* Proof V.

supply of electricity is proposed by the license to be furnished, given in the case of each such local authority in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce in the case of each such local authority a certificate signed by the secretary or clerk to such local authority, embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

Where application is made by a Company or person not being a Local Authority, Proof that it is made with the Consent of every Local Authority having Jurisdiction within the proposed area of supply.

E. L. Act, sec. 3 (1) and Rules 1 and 7.

IV.   will prove that the application for a license is made with the consent of every local authority having jurisdiction within the area or any part of the area within which a supply of electricity is proposed by the license to be furnished, given in the case of each such local authority in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce in the case of each such local authority a certificate signed by the secretary or clerk to such local authority embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

By affidavit or statutory declaration, with a list of the local authorities as an exhibit, and by production of the certificate or certificates.

Where the Applicants are a Local Authority, that Application is made in pursuance of a Resolution passed at a Special Meeting of such Local Authority.

E. L Act, sec. 3 (6)

V.   will prove

By production of certificate.

License Proofs.

that the application for a license is made in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce a certificate signed by the secretary or clerk to such local authority, embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

Deposits on Application.

By affidavit by statutory declaration, or personally.

Rules 3, 5 and 6.

VI. will prove that the applicants deposited at the office of the Board of Trade,—

(*a.*) A memorial, signed by or on behalf of the applicants, headed with a short title descriptive of the proposed undertaking, addressed to the Board of Trade, and praying for a license.

(*b.*) Six copies of the printed draft of the license as proposed by the applicants, with the schedule or schedules (if any) referred to therein.

(*c.*) A list of the local authorities in whose districts the area of supply is situate.

(*d.*) A list of the streets not repairable by a local authority, and of the railways and tramways (if any) which the applicants propose to take powers to break up.

(*e.*) A list of the canals and navigable rivers (if any) which the undertakers will be empowered under the license to cross.

(*f.*) A statement of the capital proposed to be expended and employed in connexion with the undertaking, and the mode in which such capital is to be provided.

(*g.*) If the applicants are a company incorporated under the provisions of the Companies' Acts, a copy of the memorandum and articles of association.

(*h.*) A fee of 50*l.* by cheque payable to an

License Proofs.

"Assistant Secretary of the Board of Trade."

(*i.*) A published map of the district on a scale of not less than one inch to a mile, or if there is no published map, then the best map procurable showing the boundaries of the proposed area of supply, and the streets and other places in, over, or along which it is proposed to place any electric lines or other works.

Rule 4.

VII. will prove in regard to the draft license :

By affidavit or statutory declaration.

(*a.*) That the drafts of the proposed license are in the form required by Rule 4, and contain a notice at the end of the draft, stating that objections are to be made by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it, " Electric Lighting Act," and that such letter is to be sent to the Board of Trade within two months from the date of the newspaper containing the first advertisement of the application.

(*b.*) That the draft contains amongst other things,—

1. Address and description of the applicants.
2. A description of the proposed area of supply.
3. A statement of the purposes for which a supply is to be given, viz., any or all of the public or private purposes specified in section *three* of the Act.
4. A general description of the proposed works.
5. Provisions concerning the breaking up of streets not repairable by a local authority and concerning interference with railways and tramways, where powers are sought to be obtained by the license for those purposes.
6. Conditions of supply, including price

E. L. Act, sec. 3, Rule 4.

E. L. Act, sec. 13, Rule 4.

License Proofs.

nature and amount of supply, obligation to supply, &c.

7. Period for which concession is sought.
8. Provisions for securing the safety of the consumer and of the public from injury by shock, fire, or otherwise.
9. Provisions for enforcing the performance by the undertakers of their duties in relation to the supply of electricity and for the revocation of the license where the undertakers fail to perform such duties.

By affidavit, by statutory declaration, or personally.

VIII. will prove that a sufficient number of printed copies of the draft license were deposited at the office in London, and also at the office within the proposed area of supply specified in the advertisement hereinafter referred to, such copies to be there furnished, at the price of not more than one shilling each, to all persons applying for them. **Rules 4 and 9.**

By affidavit, by statutory declaration, or by production of the receipts.

IX. will prove that the applicants did deposit for public inspection:— **Rule 5.**

a. (*If in England or Ireland.*) At the office of the Clerk of the peace for every county, riding, or division, and of the local authority of every district.

b. (*If in Scotland.*) At the office of the principal sheriff clerk for every county, district, or division, and of the local authority of every district,

in which the proposed area of supply or any part thereof is situate, a published map of the district on a scale of not less than one inch to a mile, or if there is no published map, then the best map procurable showing the boundaries of the proposed area of supply, and the streets and other places in, over, or along which it is proposed to place any electric lines or other works.

License Proofs.

Advertisements after Application is Entertained by Board of Trade.

E. L. Act, sec. 3 (5), Rule 9.

X. will prove the publication in the following newspapers; viz.,
The
Gazette of the
and the
of the
and of the of the notice, which is prescribed by subsection 5, section 3, of the Act, of the application for a license, and (if not already furnished) will produce a copy of the Gazette and newspapers containing such notice.

By production of the documents.

E. L. Act, sec. 3 (5), Rule 9.

XI. will prove that the published notices are copies of each other, and that they contain the following particulars:—

By affidavit or statutory declaration.

1. The objects of the application.
2. Address and description of applicants.
3. A general description of the nature of the proposed works.
4. A description of the proposed area of supply.
5. The names of the streets and other places in, over, or along which it is proposed to place any electric lines or other works.
6. A list of the streets not repairable by a local authority and of the railways and tramways (if any) which the applicants propose to take powers by the license to break up.
7. A list of the canals and navigable rivers which the undertakers will be empowered under the license to cross.
8. The address of an office in London, and of another office within the proposed area of supply, at which printed copies of the draft license, and of the license when made, can be obtained at a price of not more than one shilling each.

License Proofs.

By affidavit or by statutory declaration. XII. will prove that the whole notice was included in one advertisement, headed with a short title descriptive of the undertaking corresponding with that at the head of the memorial. Rule 9.

„ „ XIII. will prove that the advertisement was inserted once at least in each of two successive weeks in some one and the same newspaper published and circulating in the proposed area of supply; or (as the case may be) in such other newspaper as the Board of Trade may have directed, and will produce such written direction. ”

„ „ XIV. will prove that the advertisements state that every local or other public authority, company, or person desirous of making any representation to the Board of Trade, or of bringing before them any objection respecting the application, may do so by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it "Electric Lighting Act," within two months from the date of the newspaper containing the first advertisement. „

Acquirement of Lands.

By affidavit, by statutory declaration, or personally, and by production of the contracts. XV. will prove that the applicants have deposited at the office of the Board of Trade a description of the lands (if any) which they propose to purchase for the purposes of the license, and must produce to the Board of Trade the contracts for the purchase of all such lands. E. L. Act, sec. 10. Rule 12.

Board of Trade (Railway Department),
December, 1882.

(B) PROVISIONAL ORDERS.

THE ELECTRIC LIGHTING ACT, 1882.

Page 8.

(*Proofs required by the Board of Trade of due compliance by the applicants with the requirements. These proofs must be prepared before January 25th. After that day, six days' notice will be given to the applicants to attend and give in their proofs, which must be completed on or before Feb. 25th. This form should be filled up and brought to the Board of Trade with the requisite documents, at the time fixed for receiving the proofs, Rule XIV.*)

SESSION 1883.

BOARD OF TRADE, RAILWAY DEPARTMENT.

NOTE—1. *The particulars not applicable should be struck out and marked inapplicable.*

2. *Proof must be given in the manner specified in the margin.*

3. *Statutory declarations must be stamped.*

PROOFS

Required by the Board of Trade of Compliance with the Provisions of the Electric Lighting Act, 1862, and the Rules made by the Board of Trade under that Act.

I. TITLE OF PROVISIONAL ORDER.

DISTRICT.

ELECTRIC LIGHTING.

II. NAME OF PROMOTERS.

Notices to be Served on Local Authorities within One Month from the Passing of the Act.

E. L. Act, 1822, sec. 4 (1), Rule 8.

III. will prove that, within one month after the passing of the Electric Lighting Act, 1882, the notice prescribed by section 4, sub-section 1, of that Act, that a

By affidavit or statutory declaration, with a list of local authorities as an exhibit, and by production of a copy of the notice.

Provisional Order is intended to be applied for was served upon every local authority (not being themselves the undertakers) within whose district it is proposed that the supply of electricity should be authorised, that such notice was given in writing, and was served, either by leaving the same at the offices of the said local authority on or before the appointed day, or by forwarding the same by post in a registered letter so that the same would in ordinary course of post be delivered on or before the appointed day.

Where the Undertakers are a local authority, that the Application is made in pursuance of a Resolution passed at a Special Meeting of such Local Authority.

By production of certificate.

E. L. Act, sec. 3 (6), Rule 7.

IV. will prove that the application for a Provisional Order is made in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce a certificate signed by the secretary or clerk to such local authority, embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

Advertisements in October or November.

By production of the documents.

E. L. Act, sec. 3 (5), Rule 9.

V. will prove the publication in October or November in the following newspapers: viz., The
Gazette of the
and the
of the
and of the of the notice, which is prescribed by sub-section 5, section 3, of the Act, of the intention of the promoters to apply for a provisional order, and (if not already furnished) will produce a copy of the gazette and newspapers containing such notice.

License Proofs.

supply of electricity is proposed by the license to be furnished, given in the case of each such local authority in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce in the case of each such local authority a certificate signed by the secretary or clerk to such local authority, embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

Where application is made by a Company or person not being a Local Authority, Proof that it is made with the Consent of every Local Authority having Jurisdiction within the proposed area of supply.

E. L. Act, sec. 3 (1) and Rules 1 and 7.

IV. will prove that the application for a license is made with the consent of every local authority having jurisdiction within the area or any part of the area within which a supply of electricity is proposed by the license to be furnished, given in the case of each such local authority in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce in the case of each such local authority a certificate signed by the secretary or clerk to such local authority embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

By affidavit or statutory declaration, with a list of the local authorities as an exhibit, and by production of the certificate or certificates.

Where the Applicants are a Local Authority, that Application is made in pursuance of a Resolution passed at a Special Meeting of such Local Authority.

E. L. Act, sec. 3 (6) Rule 7.

V. will prove

By production of certificate.

License Proofs.

that the application for a license is made in pursuance of a resolution passed at a special meeting of the local authority held after one month's previous notice of the same, and of the purpose thereof, had been given in the manner in which notices of meetings of such local authority are usually given, and will produce a certificate signed by the secretary or clerk to such local authority, embodying copies of the notice and of the resolution, and certifying that the notice was duly given and the resolution duly passed.

Deposits on Application.

By affidavit by statutory declaration, or personally.

VI. will prove that the applicants deposited at the office of the Board of Trade,— Rules 3, 5 and 6.

(*a.*) A memorial, signed by or on behalf of the applicants, headed with a short title descriptive of the proposed undertaking, addressed to the Board of Trade, and praying for a license.

(*b.*) Six copies of the printed draft of the license as proposed by the applicants, with the schedule or schedules (if any) referred to therein.

(*c.*) A list of the local authorities in whose districts the area of supply is situate.

(*d.*) A list of the streets not repairable by a local authority, and of the railways and tramways (if any) which the applicants propose to take powers to break up.

(*e.*) A list of the canals and navigable rivers (if any) which the undertakers will be empowered under the license to cross.

(*f.*) A statement of the capital proposed to be expended and employed in connexion with the undertaking, and the mode in which such capital is to be provided.

(*g.*) If the applicants are a company incorporated under the provisions of the Companies' Acts, a copy of the memorandum and articles of association.

(*h.*) A fee of 50*l.* by cheque payable to an

License Proofs.

"Assistant Secretary of the Board of Trade."

(*i.*) A published map of the district on a scale of not less than one inch to a mile, or if there is no published map, then the best map procurable showing the boundaries of the proposed area of supply, and the streets and other places in, over, or along which it is proposed to place any electric lines or other works.

Rule 4.

VII. will prove in regard to the draft license:

By affidavit or statutory declaration.

(*a.*) That the drafts of the proposed license are in the form required by Rule 4, and contain a notice at the end of the draft, stating that objections are to be made by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it, "Electric Lighting Act," and that such letter is to be sent to the Board of Trade within two months from the date of the newspaper containing the first advertisement of the application.

(*b.*) That the draft contains amongst other things,—

1. Address and description of the applicants.
2. A description of the proposed area of supply.
3. A statement of the purposes for which a supply is to be given, viz., any or all of the public or private purposes specified in section *three* of the Act.
4. A general description of the proposed works.
5. Provisions concerning the breaking up of streets not repairable by a local authority and concerning interference with railways and tramways, where powers are sought to be obtained by the license for those purposes.
6. Conditions of supply, including price

E. L. Act, sec. 3, Rule 4.

E. L. Act, sec. 13, Rule 4.

nature and amount of supply, obligation to supply, &c.
7. Period for which concession is sought.
8. Provisions for securing the safety of the consumer and of the public from injury by shock, fire, or otherwise.
9. Provisions for enforcing the performance by the undertakers of their duties in relation to the supply of electricity and for the revocation of the license where the undertakers fail to perform such duties.

By affidavit, by statutory declaration, or personally.

VIII. will prove that a sufficient number of printed copies of the draft license were deposited at the office in London, and also at the office within the proposed area of supply specified in the advertisement hereinafter referred to, such copies to be there furnished, at the price of not more than one shilling each, to all persons applying for them. **Rules 4 and 9.**

By affidavit, by statutory declaration, or by production of the receipts.

IX. will prove that the applicants did deposit for public inspection:— **Rule 5.**

a. (*If in England or Ireland.*) At the office of the Clerk of the peace for every county, riding, or division, and of the local authority of every district.

b. (*If in Scotland.*) At the office of the principal sheriff clerk for every county, district, or division, and of the local authority of every district,

in which the proposed area of supply or any part thereof is situate, a published map of the district on a scale of not less than one inch to a mile, or if there is no published map, then the best map procurable showing the boundaries of the proposed area of supply, and the streets and other places in, over, or along which it is proposed to place any electric lines or other works.

License Proofs.

Advertisements after Application is Entertained by Board of Trade.

E. L. Act, sec. 3 (5), Rule 9.

X. will prove the publication in the following newspapers; viz.,

By production of the documents.

The
Gazette of the
and the
of the
and of the of the notice, which is prescribed by subsection 5, section 3, of the Act, of the application for a license, and (if not already furnished) will produce a copy of the Gazette and newspapers containing such notice.

E. L. Act, sec. 3 (5), Rule 9.

XI. will prove that the published notices are copies of each other, and that they contain the following particulars:—

By affidavit or statutory declaration.

1. The objects of the application.
2. Address and description of applicants.
3. A general description of the nature of the proposed works.
4. A description of the proposed area of supply.
5. The names of the streets and other places in, over, or along which it is proposed to place any electric lines or other works.
6. A list of the streets not repairable by a local authority and of the railways and tramways (if any) which the applicants propose to take powers by the license to break up.
7. A list of the canals and navigable rivers which the undertakers will be empowered under the license to cross.
8. The address of an office in London, and of another office within the proposed area of supply, at which printed copies of the draft license, and of the license when made, can be obtained at a price of not more than one shilling each.

License Proofs.

By affidavit or by statutory declaration. XII. will prove that the whole notice was included in one advertisement, headed with a short title descriptive of the undertaking corresponding with that at the head of the memorial. Rule 9.

" " XIII. will prove that the advertisement was inserted once at least in each of two successive weeks in some one and the same newspaper published and circulating in the proposed area of supply; or (as the case may be) in such other newspaper as the Board of Trade may have directed, and will produce such written direction. "

" " XIV. will prove that the advertisements state that every local or other public authority, company, or person desirous of making any representation to the Board of Trade, or of bringing before them any objection respecting the application, may do so by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it "Electric Lighting Act," within two months from the date of the newspaper containing the first advertisement. "

Acquirement of Lands.

By affidavit, by statutory declaration, or personally, and by production of the contracts. XV. will prove that the applicants have deposited at the office of the Board of Trade a description of the lands (if any) which they propose to purchase for the purposes of the license, and must produce to the Board of Trade the contracts for the purchase of all such lands. E. L. Act, sec. 10. Rule 12.

Board of Trade (Railway Department),
December, 1882.

Memorandum, Feb. 26, 1883.

standard system in these clauses, and it is not proposed at first to give a right either to the local authority or to private consumers to demand a supply for public or private lighting on any other system: the provision is made that with the approval of the Board of Trade any other system may be substituted. Of course by agreement any system whatever may be employed, provided that it complies with the regulations as to safety and otherwise, special provision being made in the clauses that if it is desired to supply at high tension for arc lighting or other purposes this may be done under special regulations.

4. *As to Time of Supply.*

It is proposed that this should be continuous, subject to six months' grace upon first commencing supply, when the undertakers need only supply between sunset and sunrise, and to a power on the part of the Board of Trade to permit special intermissions for the purposes of testing or otherwise. It may, however, be well for local authorities to consider in every case how far continuous supply is desirable for their district; as, however necessary it may be thought in crowded cities, where artificial light may probably be in constant demand, where there is only a slight demand in the daytime, as in country towns, the small additional convenience may not improbably be more than counterbalanced by the much higher price which must almost of necessity be charged for electricity where there is a continuous instead of an intermittent supply.

5. *As to Price.*

It is proposed that electricity should in all cases be charged for by meter; but as at present it seems doubtful whether there is any reliable meter for quantity or energy, a power is given to the undertakers to charge for the present, and until the Board of Trade otherwise direct, by the maximum current required, and the number of hours during which electricity is used. The latter, however, does not seem a very satisfactory mode of charging, and it is hoped it may soon be dispensed with, as there seems to be no doubt that meters for quantity and energy will soon be perfected for practical use.

6. *As to Limitation of Profits, Revision of Prices, Monopoly, &c.*

No clauses are inserted dealing with the above subjects. In the case of companies the undertaking can be purchased by the

Memorandum, Feb. 26, 1883.

local authority at farthest at the end of 21 years at the then value of the plant. In the meantime there is, in the first place, the competition with gas, which is likely to be very severe; and, in the second place, the potential competition with other undertakers to keep down prices, as the Board of Trade see no reason whatever why such last-mentioned competition should not be an active and potent force. The accounts of the undertakers are open to all. No monopoly is, under the Act or the Provisional Order, granted or intended to be granted to them; and should they neglect their duties in the district, or charge exorbitant prices, there is nothing to prevent the immediate grant of a license or Provisional Order to a competing set of undertakers within the same district. In the case of local authorities there will be not only competition to look to, but also public opinion, and the Board of Trade prefer to rely upon the above considerations rather than to attempt to impose artificial restrictions, which, in other cases, have not proved too successful.

N.B.—*Any person desirous of offering any criticisms or suggestions with regard to these clauses is requested to do so by letter, addressed to the Board of Trade, and marked on the outside of the cover enclosing it "Electric Lighting Act," on or before the* 14*th day of March next.*

Board of Trade, T. H. Farrer.
26th February, 1883.

(Then follow the proposed model clauses. As however these have been modified they are here omitted, and the reader is referred to the order issued in April, 1883, page 98.)

PROVISIONAL ORDER.

(*The following is the form of Provisional Order about to be issued to the Brush Company enabling them to light that part of the parish of Chelsea which lies north of Pont-street and Grove-place. It is of course subject to alteration by Parliament at the instance of any interested parties, but it supplies a model of the form which is intended to be adhered to as far as possible; but of course in different districts, and with different undertakers, the provisions will vary, especially where the undertakers are a local authority. The form of a license will probably very closely resemble that of the provisional order. Note also that draft licenses or orders must have appended to them the notice required by Rule IV. See form* 11.)

Provisional Order. Chelsea.

CHELSEA ELECTRIC LIGHTING.

TABLE OF CONTENTS.

Preliminary.

Clause.
1. Short title.
2. Interpretation.
3. Commencement of order.

Address and Description of the Undertakers.

4. Address and description of undertakers.

Area of Supply.

5. Area of supply.
6. Extension of area of supply.
7. Removal of certain parts of area included in schedule B. from operation of order.

Capital. (*See Memorandum, Clause* 2.)

8. Separate capital for undertaking.
9. Separate capital to be increased when area of supply added to.
10. Separate capital to be applied for purposes of undertaking.

Nature and Mode of Supply.

11. Description of systems of supply.

Works.

12. Powers for execution of works.
13. Notice of works, with plan, to be served on the Postmaster-General and local authority.
14. As to breaking up private streets, railways, &c.

Clause.
15. As to alteration of pipes, wires, &c. under streets.
16. For protection of telephone companies, &c.

Powers of Undertakers as to breaking up streets, &c. may bé exercised by Local Authority.

17. Local authority may give notice of desire to break up streets, &c. on behalf of undertakers.
18. Proceedings where local authority give such notice.

Compulsory Works.

19. Mains, &c. to be laid down in certain streets specified in Schedule A. within two years.
20. Mains, &c. to be laid down in remainder of area in Schedule A. on requisition.
21. If undertakers fail to lay down mains, &c. order may be revoked.
22. Mains, &c. to be laid down in area included in Schedule B. on requisition.
23. Manner in which requisition is to be made.
24. Provisions on requisition by owners or occupiers.
25. Provisions on requisition by local authority.

Maps.

26. Map of area of supply to be made.
27. Deposit and inspection of maps.
28. Penalty on undertakers and persons refusing inspection of maps.

Regulations as to Supply on the Parallel System.

29. Provisions as to parallel system. Notice of intention to supply through any distributing mains to be given to local authority. Undertakers to provide constant supply. Pressure in mains during supply. Limits of standard pressure. Fixing of standard pressure. Number of alternations in alternating currents. Supply to be given at two poles on consumer's premises. Pressure at poles on consumer's premises.

Testing.

30. Appointment of electric inspectors by local authority.
31. Appointment of electric inspectors by a court of summary jurisdiction in certain cases.
32. Remuneration of electric inspectors.
33. Testing of mains.
34. Testing of service lines.
35. Mode of testing.
36. Report of results of testing.
37. Expenses of testing.
38. Local authority to establish testing places and keep instruments.
39. Readings of instruments to be taken.
40. Undertakers may test instruments of local authority.
41. Undertakers to keep instruments.
42. Electric inspector may test undertakers instruments.
43. Representation of undertakers at testings.
44. Undertakers to give facilities for testing.

Supply.

45. Undertakers to furnish sufficient supply of electricity to owners and occupiers within the limits of the special Act.
46. Maximum current.
47. Supply of electricity to public lamps.
48. Penalty for failure to supply.

Provisional Order. Chelsea.

Clause. *Price.*

49. Methods of charging.
50. Maximum prices.
51. Other charges by agreement.
52. Price of public lamps.

Meters

53. Meters to be used except by agreement.
54. Meter to be certified.
55. Fees for certifying meters.
56. Undertakers to supply meters if required to do so.
57. Meters not to be connected or disconnected without notice.
58. Consumer to keep his meter in proper order.
59. Power to the undertakers to let meters.
60. Undertakers to keep meter let for hire in repair.
61. Differences as to correctness of meter to be settled by inspector.
62. Undertakers to pay expenses of providing new meters where method of charge altered.
63. Undertakers may place meters to measure supply or to check measurement thereof.

Regulations as to Safety.

64. Regulations to be observed by undertakers.

Notices, &c.

65. Notices, &c. may be printed or written.
66. Services of notice, &c.

Revocation of Order.

67. Revocation of order where undertakers are insolvent.
68. Provisions where order revoked.

General.

69. Nature and amount of security.
70. Proceedings where approval of Board of Trade is required.
71. Notice of approval of Board of Trade, &c. to be given by advertisement.
72. Notice of applications for extension of time to be given to local authority
73. Recovery of penalties.
74. Untertakers to be responsible for all damages.
75. As to mortgages.
76. Saving rights of the Crown in the foreshore.
77. Works not to be constructed on shore of navigable waters without consent of Board of Trade.
78. Undertakers not exempted from indictment for nuisance.
79. Provision as to general Acts.
SCHEDULES.

CHELSEA ELECTRIC LIGHTING.

Provisional Order authorising the Metropolitan (Brush) Electric Light and Power Company, Limited, to erect and maintain Electric Lines and Works, and to supply Electricity within the Parish of Chelsea, in the County of Middlesex.

Preliminary.

Short title. 1. This order may be cited as "The *Chelsea* Electric Lighting Order, 1883."

Interpretation.

2. This order is to be read and constructed subject in all respects to the provisions of the Electric Lighting Act, 1882, and of any other Acts or parts of Acts incorporated therewith, which said Acts and parts of Acts are in this Order collectively referred to as "the principal Act"; and the several words, terms, and expressions to which by that Act meanings are assigned shall have in this Order the same respective meanings, provided that in this Order—

E. L. Act, secs. 31, 32.

The expression "main" shall mean any continuous metallic conductor which may be laid down by the undertakers in any street or public place, and through which electricity may be supplied, or intended to be supplied by the undertakers for the purposes of general supply or for charging storage batteries used for the purposes of general supply

The expression "service line" shall mean any continuous metallic conductor through which electricity may be supplied, or intended to be supplied by the undertakers to any particular consumer on the parallel system, either from any main or directly from the premises of the undertakers:

The expression "charging main" shall mean a main which for the time being is being used solely for the purpose of charging storage batteries:

The expression "distributing main" shall mean the portion of any main which is used for the purpose of giving origin to service lines for the purposes of general supply:

The expression "general supply" shall mean the supply of electricity to ordinary consumers, and, unless otherwise specially agreed with the local authority, to the public lamps, but shall not include the supply of electricity to any one or more particular consumers under special agreement.

The expressions "Schedule A.," "Schedule B.," and "Schedule C.," shall mean the Schedules A., B., and C. to this order annexed respectively.

Commencement of order.

3. This order shall come into force and have effect upon the day when the Act confirming this order is passed, which date is in this order referred to as "the commencement of this order."

Address and Description of the Undertakers.

Address and description of undertakers.

4. The undertakers for the purpose of this order are the *Metropolitan (Brush) Electric Light and Power Company, Limited, being a Company registered under the Companies Acts,* 1862 *to*

Provisional Order. Chelsea.

1880, *with limited liability, and having its registered office at No. 110, Cannon Street, in the City of London, and having its capital divided into* 200,000 *shares of 5l. each.* Provided that if the undertaking or any part thereof is at any time transferred to any other body or persons in accordance with the provisions of this order, or of the principal Act, such body or persons shall, from the date of such transfer, be the undertakers in relation to such undertaking or part thereof for the purposes of this order in lieu of the Company above mentioned.

Area of Supply.

Area of supply.

E. L. Act, sec. 4. See also clause 19 of this order.

5. The area within which the undertakers are authorised to supply electricity under this order shall be the whole of the area included in Schedule A. (which said area is more particularly delineated upon the map deposited at the Board of Trade by the undertakers together with this order, and thereon coloured yellow) together with so much of the area included in Schedule B. (which said area is more particularly delineated upon the map above mentioned and thereon coloured blue) as may hereafter be added to the area of supply in accordance with the direction of the Board of Trade as by this order provided.

Extension of area of supply.

E. L. Act, sec. 6 (*a*), clause 22 of this order.

6. At any time after the commencement of this order the undertakers may apply to the Board of Trade to direct that any part or parts of the area included in Schedule B., and not removed from the operation of this order as hereinafter mentioned, shall be added to the area of supply.

Notice of every such application shall be published by public advertisement once at least in each of two successive weeks in some one and the same local newspaper, and shall be served upon the local authority.

When any such application has been made the Board of Trade upon being satisfied that such notice has been duly published, and served as aforesaid, and after giving an opportunity to the local authority to make representations or objections with reference to the application, may, at the expiration of a period of three months after the publication of the first of such advertisements, direct all or any part of the additions to the area of supply therein specified to be made, and the area of supply shall be extended accordingly: Provided that if the Board of Trade are of opinion that such additions or some of them have not been reasonably or fairly selected, having regard to the future development of electric lighting in the district, they may refuse to direct the same to be added to the area of supply, except upon the terms that some other part or parts of the area included in Schedule B. should also be added to the area of supply.

Removal of certain parts of area included in schedule B. from operation of order.

7. If at any time after the expiration of a period of two years after the commencement of this order the local authority should be desirous that any part or parts of the area included in Schedule B. which may not for the time being be included in the area of supply should be added to the area of supply, they may serve a notice upon the undertakers requiring them to apply to the Board of Trade to direct that such part or parts as particularly specified in such notice shall be added to the area of supply; and if the undertakers for the period of three months after the service of such notice upon them as aforesaid refuse or neglect to apply to the Board of Trade to direct that such part or parts shall be added to the area of supply in compliance with the terms of such notice, the Board of Trade, upon the application of the local authority, and upon being satisfied that such notice has been duly served, and that such refusal or neglect has continued for the period aforesaid, may direct that such part or parts, or any portion thereof, be removed from the operation of this order, either absolutely or subject to the contingency of a license or provisional order being obtained by some local authority, or by some company or person, authorising them to supply electricity within such part or parts or portion thereof, and may order any costs and expenses incurred by the local authority in connection with any such application by them as aforesaid to be paid to the local authority by the undertakers; and where any such part or parts or portion thereof may have been removed from the operation of this order under the provisions of this section, the powers of the undertakers to apply to the Board of Trade to direct that such part or parts or portion thereof, as the case may be, shall be added to the area of supply shall absolutely cease and determine from and after the date when such removal is directed to take place.

This division of the area into a compulsory area, and one which either the undertakers or, after an expiration of two years, the local authority or private consumers, may compel the undertakers to extend, is not prescribed by the Act. It is a matter of convenience. It may have the effect of postponing the electric lighting of the parts of the area in Schedule B for two years, and practically preventing any other electric lighting company from coming there. On the other hand, it subjects the undertakers to be compelled to light them after the expiration of two years on the application of the local authority or private consumers, and this may be a very onerous liability.

Capital (only Applicable to Companies, see Memorandum, February 26th, Clause 2).

Separate capital for undertaking.

8. The undertakers, within a period of six months after the commencement of this order, and before exercising any of the powers by this order conferred on them in relation to the execution of works, shall cause a sum of not less than *thirty thousand* pounds to be appropriated as a separate capital for the purposes of the undertaking, such appropriation being effected either by a special resolution setting aside a portion of the capital of the undertakers, or in such other manner as may be approved of by the Board of Trade, with the consent of the local authority, and they shall also within the period aforesaid deposit or secure to the satisfaction of the Board of Trade a sum of not less than *fifteen thousand* pounds in respect of the said sum so appropriated as aforesaid.

Note.—The amount to be appropriated should be such amount as seems reasonably sufficient to be a sufficient guarantee for the provision of a supply of electricity as required throughout the whole of the area included in Schedule A., not exceeding three-fourths of the estimated cost of the works necessary for the purpose. The amount to be deposited or secured should not exceed one-half the amount required to execute the works necessary for supplying the streets, &c., specially mentioned in Schedule A., and which are to be executed under this order within two years.

If the undertakers fail to appropriate or to deposit or secure any such sum as aforesaid in accordance with the provisions of this section within the said period of six months, or such extended period as may from time to time be approved of by the Board of Trade, this order may be revoked by the Board of Trade upon such terms as they may think just.

Any sum deposited or secured by the undertakers under the provisions of this section shall be repaid or released to them from time to time in sums of not less than *one thousand* pounds, when and so soon as it may be certified by an inspector to be appointed by the Board of Trade, that amounts equal to the sums so to be released or repaid have been expended by the undertakers upon works executed for the purposes of the undertaking, or that distributing mains have been duly laid down in accordance with the provisions of this order in every street or part of a street specified in that behalf in Schedule A., or at such earlier dates and by such instalments as may from time to time be approved of by the local authority.

The cost of an electric installation is about *4l.* to *5l.* per incandescent lamp. The above sum would therefore not go very far; but no doubt it is as much as the undertakers could be expected to engage to expend

for the present. This rule gives the undertakers six months after they get their order, to consider whether they will carry it out.

Separate capital to be increased when area of supply added to.

9. Where any part or parts of the area included in Schedule B. may be hereafter added to the area of supply by the direction of the Board of Trade under the provisions of this order, the undertakers, within a period of six months after the date when such addition is directed to take effect, and before exercising any of the powers by this order conferred on them in relation to the execution of works within the part or parts so added, shall cause the separate capital appropriated for the purposes of the undertaking to be increased by a sum not less than such sum as may be prescribed in that behalf by the Board of Trade, such appropriation being effected in some such manner as in the last section mentioned, and shall also within the period aforesaid deposit and secure to the satisfaction of the Board of Trade a sum not less than such sum as may be prescribed in that behalf by the Board of Trade in respect of the said increase of the separate capital so prescribed as aforesaid.

If in any case the undertakers fail to appropriate or to deposit or secure the sums prescribed in that behalf respectively as aforesaid, in accordance with the provisions of this section within the said period of six months after the date when any such addition as aforesaid has been directed to take effect, or such extended period as may from time to time be approved of by the Board of Trade, this order may be revoked by the Board of Trade upon such terms as they may think just.

Any sum deposited or secured by the undertakers under the provisions of this section, shall be repaid or released to them when and so soon as they have executed such works (if any) as may be prescribed in that behalf by the Board of Trade, or at such earlier dates and by such instalments as may be approved of by the local authority.

Separate capital to be applied for purposes of undertaking.

E. L. Act, sec. 9.

10. The undertakers shall, except with the special approval of the Board of Trade, to be previously given, at all times cause such sums as may have been appropriated as a separate capital for the purposes of the undertaking, together with such increases thereof as may from time to time be made in accordance with the provisions of the last preceding section, to be kept appropriated for the said purposes, and shall keep accounts thereof distinct from the accounts kept by them in respect of any other undertaking.

E. L. Act, sec. 6 (*f.*)

If the undertakers make default in complying with any of the requirements of this section in respect of the appropriation of any capital for the purposes of the undertaking, this order may be

Provisional Order. Chelsea.

revoked by the Board of Trade, if they think fit, upon such terms as they may think just.

Nature and Mode of Supply.

Description of systems of supply.
E. L. Act, sec. 3, sub-secs. 3, 4.

11. Subject to the provisions of this order and of the principal Act, the undertakers may supply electricity within the area of supply for all public and private purposes as defined by the said Act.

Such electricity may be supplied by means of any one or more of the following systems:

(*a.*) The "parallel system," that is to say, a system under which the electricity used by each consumer is drawn off from a double series of mains (in this order referred to as "the positive and negative mains"), in connexion respectively with the positive and negative poles of the immediate source of supply, by means of service lines forming a series of parallel circuits:

(*b.*) The "series system," that is to say, a system under which the whole current is utilized at various points situated successively in the same circuit, and is not divided up for the purpose of utilisation into different parallel circuits which supply different consumers:

(*c.*) Any other system which may be approved of by the Board of Trade either for general or special use.

Provided that under no such system shall the undertakers permit any part of any circuit to be connected with earth unless such connexion is hereafter approved of by the Board of Trade, with the concurrence of the Postmaster-General, either for general use or for individual cases, and then subject only to such regulations as the Board of Trade may from time to time impose.

As will be explained hereafter, the electricity may be conducted to the lamps either in one stream passing successively through them all, or in a number of parallel currents. The first of these requires electricity of high electromotive force or pressure; the second, electricity of great current strength. For, in the first case, a given amount of current will do all the work. As it passes each lamp in succession its *quantity* is not diminished, though its electromotive force is gradually worn down. Hence, though small in quantity, its electromotive force must be high. But where the current is divided into several streams, it may start with a low electromotive force, though, as it is to be divided up, its current strength, or the quantity delivered per second, must be large.

The prohibition against earth returns is no doubt due to their danger. The reason they are dangerous is as follows: If both the lead wire and the return wire are completely insulated a person standing on the ground, and touching one of them, would get no shock, for the circuit through his body would not be completed. But if there were a connexion, or leak to earth through the wire other than the one he touched, the circuit would be made through his body. No insulation can be absolutely perfect; but in proportion as it is perfect, so is the danger of shock diminished. I have seen a shopkeeper on the Holborn Viaduct touch the metal of an arc lamp, which was one of a series through which a 2000 volt current from a Brush machine was passing. The electromotive force between the two sides of the lamp was small, not being more than perhaps fifty volts, but had the dynamo been connected to earth, or had a similarly reckless person with damp shoes touched at the same instant the wire at a point sufficiently distant to obtain a considerable difference of potential, it is quite possible that they might have both been very severely injured, if not killed. For this reason all electric machinery should be well insulated, and dry boards or india-rubber mats put round all the machines.

The reason why the consent of the Postmaster-General is required for earth circuits, is because they may interfere with his telegraphs.

Works.

Power for execution of works. Gasworks Clauses Act, 1847, sec. 6.

12. Subject to the provisions of this order and the principal Act, the undertakers may from time to time exercise all or any of the powers conferred on them by this order and the principal Act, and may break up and otherwise interfere with the several streets, railways and tramways specified in Schedule D. to this order, so far as the same may be or be upon any land dedicated to public use, and they may from time to time construct distributing boxes in any street for the purpose of supplying electricity.

Every such distributing box shall be for the exclusive use of the undertakers and under their sole control, except so far as the Board of Trade may otherwise order, and shall be used by the undertakers only for the purpose of leading off service lines and other distributing conductors, or for examining, testing, regulating, measuring, directing or controlling the supply of electricity, or for examining or testing the condition of the mains or other portions of the electric lines or works, or for other like purposes connected with the undertaking, and the undertakers may place therein meters, switches, and any other suitable and proper apparatus for any of the above purposes, and may maintain and use the same.

Notice of works, with plan, to be served on the Postmaster-General and local authority. Gasworks Clauses Act, 1847, secs. 8, 9, incorporated in E. L. Act, sec. 12.

13. Where the exercise of any of the powers of the undertakers in relation to the execution of any works (including the construction of distributing boxes) will cause any interference with any street or public bridge, the following provisions shall have effect.

(*a.*) *One month* before commencing the execution of such works (not being the repairs, renewals, or amendments of existing works of which the character and position are not altered), the undertakers shall serve a notice upon the Postmaster-General and the local authority describing the proposed works, together with a plan of the works showing the mode and position in which such works are intended to be executed, and the manner in which it is intended that such street or bridge, or any sewer, drain, or tunnel therein or thereunder should be interfered with, and shall, upon being required to do so by the Postmaster-General or the local authority, from time to time give them any such further information in relation thereto as he or they may desire.

E. L. Act, sec. 26, and Telegraph Act, 1878.

(*b.*) The Postmaster-General or the local authority may in his or their discretion approve of any such works or plan, with or without any amendments or alterations, or disapprove the same, and may give notice of such approval or disapproval to the undertakers.

(*c.*) Where the Postmaster-General or the local authority disapprove of any such works or plan, the undertakers may appeal to the Board of Trade against such disapproval, and the Board of Trade may allow or disallow such appeal, and approve any such works or plan, with or without any amendments or alterations, or disapprove the same: Provided that nothing in this section shall authorise the undertakers to place any electric line above ground, along, over, or across any street without the express consent of the local authority.

E. L. Act, sec. 14.

(*d.*) If the Postmaster-General or the local authority fail to give any such notice of approval or disapproval to the undertakers within *three* weeks after the service of the notice upon them, he or they shall be deemed to have approved of such works or plan.

(*e.*) Notwithstanding anything in this order or the principal Act, the undertakers shall not be entitled to execute any such works as above specified, except so far as the same may be of a description and in accordance with a plan which has been approved or is to be deemed to have been approved by the Postmaster-General and the local authority, or by the Board of Trade as above mentioned under this order; but where any such works and such plan are so approved, or to be deemed to be approved, the undertakers may proceed to execute such works in accordance with such plan, subject in all respects to the provisions of this order and of the principal Act.

(*f.*) If the undertakers make default in complying with any of the requirements or restrictions of this section, they shall (in addition to any other compensation which they may be liable to make under the provisions of this order or the principal Act) make full compensation to the Postmaster-General and the local authority for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues, provided that the undertakers shall not be subject to any such forfeitures as aforesaid if the court having cognizance of the case are of opinion that the case was one of emergency, and that the undertakers complied with the requirements of this section so far as was reasonable under the circumstances. **E. L. Act, sec. 17.**

These provisions must be considered as *pro tanto* superseding the provisions as to notice to the local authorities contained in the Gasworks Clauses Act, 1847, and to the Postmaster-General in sec. 26 of the Electric Lighting Act, 1882, and the Telegraph Act, 1878.

Overhead wires are chiefly objectionable as hampering fire-escapes. They are also very unsightly, and may be removed when dangerous by Justices of the Peace. (Electric Lighting Act, sec. 14.)

Streets when opened up must be reinstated without delay. (Gasworks Clauses Act, 1847, sec. 10.)

As to streets not repairable by the local authority, railways, &c.

14. Where the exercise of the powers of the undertakers in relation to the execution of any works will involve the placing of any works in, over, along, or across any street or part of a street not repairable by the local authority, or over or under any railway, tramway, or canal the following provisions shall have effect.

(*a.*) One month before commencing the execution of any such works (not being the repairs, renewals, or amendments of existing works of which the character and position are not altered) the undertakers shall, in addition to any other notices which they may be required to give under this order or the principal Act, serve a notice upon the persons liable to repair such streets, or parts of streets, or the persons for the time being entitled to work such railway or tramway or the owners of such canal (as the case may be), describing the proposed works, and stating the amount of compensation proposed to be made in respect thereof, and the manner in which such compensation is proposed to be paid or secured, together with a plan of the works showing the mode and position in which such works are intended to be executed and placed, and shall, upon being required to do so by any such persons as aforesaid, from time to time give them any such further information in relation thereto as they may desire.

(*b.*) Within three weeks after the service of any such notice and plan upon any owners, such owners may, if they think fit, serve a requisition upon the undertakers requiring that any question in relation to such works, and any other question arising upon such notice or plan aforesaid shall be settled by arbitration; and thereupon such question shall be settled by arbitration accordingly.

(*c.*) In settling any question under this section an arbitrator shall have regard to any duties or obligations which the owners may be under in respect of such street, railway, or tramway, and may, if he thinks fit, require the undertakers to execute any temporary or other works so as to avoid interference with any traffic so far as may be possible.

(*d.*) Where no such requisition as in this section mentioned is served upon the undertakers, or where, after any such requisition has been served upon them, any question required to be settled by arbitration has been so settled, the undertakers upon paying or securing any compensation which they may be required to pay or secure in the manner proposed by them or settled by arbitration as aforesaid may cause the works specified in such notice and plan as aforesaid to be executed, and may from time to time repair, renew, and amend the same (provided that their character and position are not altered), but subject in all respects to the provisions of this order and the principal Act, and only in accordance with the notice and plan so served by them as aforesaid or such modifications thereof respectively as may have been settled by arbitration as hereinbefore mentioned, or as may be agreed upon between the parties.

(*e.*) If the undertakers make default in complying with any of the requirements or restrictions of this section they shall (in addition to any other compensation which they may be liable to make under the provisions of this order or the principal Act) make full compensation to the owners affected thereby for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues; provided that the undertakers shall not be subject to any such forfeiture as aforesaid if the court having cognizance of the case are of opinion that the case was one of emergency, and that the undertakers complied with the requirements of this section so far as was reasonable under the circumstances.

E. L. Act, sec. 17.

By "private streets" it is not meant that private streets may be broken up over which the public have no right of way. It is only meant that such streets not repairable by the local authority as are specified in schedule D. may be broken up, and as to which special leave has been obtained. (See note to secs. 6 and 7 of the Gasworks Clauses Act, 1847, and clause 12, p. 107.)

(*e.*) These provisions must be taken as replacing the penalties imposed by the Gasworks Clauses Act, 1847, sec. 11.

15. The undertakers may from time to time alter the position of any pipes or wires being under any street or place authorised to be broken up by them which may interfere with the exercise of their powers under the principal Act or this order; and any local or other public authority, company, or person may in like manner alter the position of any electric lines or works of the undertakers, being under any such street or place as aforesaid, which may interfere with the lawful exercise of any powers vested in such local authority, company, or person in relation to such street or place, subject to the following provisions:—

As to alteration of pipes, wires, &c., under streets. Gasworks Clauses Act, 1847. E. L. Act, sec. 7.

(*a.*) One month before commencing any such alteration the undertakers, or such local or other public authority, company, or person (as the case may be), in this section

Provisional Order. Chelsea.

referred to as "the operators," shall serve a notice upon the body or person for the time being entitled to such pipes, wires, electric lines, or works (as the case may be), in this section referred to as "the owners," describing the proposed alteration, and stating the amount of compensation proposed to be made in respect thereof, and the manner in which such compensation is proposed to be paid or secured, together with a plan showing the manner in which it is intended that such alterations shall be made, and shall, upon being required to do so by any such owners, from time to time give them any such further information in relation thereto as they may desire.

(*b.*) Every such notice shall contain a reference to this section, and direct the attention of the owners to whom it is given to the provisions thereof.

(*c.*) Within three weeks after the service of any such notice and plan upon any owners, such owners may, if they think fit, serve a requisition upon the operators, requiring that any question arising upon such notice or plan as aforesaid shall be settled by arbitration, and thereupon such question shall be settled by arbitration accordingly.

(*d.*) In settling any question under this section an arbitrator shall have regard to any duties or obligations which the owners may be under in respect of such pipes, wires, electric lines, or works, and may, if he thinks fit, require the operators to execute any temporary or other works so as to avoid interference with any purpose for which such pipe, wire, electric line, or work is used so far as may be possible.

(*e.*) Where no such requisition as in this section mentioned is served upon the operators, the owners shall be held to have agreed to the notice or plan served on them as aforesaid, and in such case, or where, after any such requisition has been served upon them, any question required to be settled by arbitration has been so settled, the operators upon paying or securing any compensation which they may be required to pay or receive in the manner proposed by them or settled by arbitration as aforesaid, may cause the alterations therein specified in such notice or plan as aforesaid to be made, but subject in all respects to the provisions of this order and the principal Act, and only in accordance with the notice and plan so served by them as aforesaid, or such modifications thereof

Provisional Order. Chelsea.

respectively as may have been settled by arbitration as hereinbefore mentioned, or as may be agreed upon between the parties.

(*e.*) At any time before any operators are entitled to commence any such alterations as aforesaid the owners may serve a statement upon them, stating that they desire to execute such alterations themselves, and where any such statement has been served upon the operators they shall not be entitled to proceed themselves to execute such alterations except where they have notified to such owners that they require them to execute such alterations, and such owners have refused or neglected to comply with such notification as hereinafter provided.

(*f.*) Where any such statement as last aforesaid has been served upon the operators, they shall not more than forty-eight hours and not less than twenty-four hours before the execution of such alterations is required to commence, serve a notification upon the owners stating the time when, and the manner in which such alterations are required to be made.

(*g.*) Upon receipt of any such notification as last aforesaid, the owners may proceed to execute such alterations as required by the undertakers subject to the like restrictions and conditions as the undertakers would themselves be subject to in executing such alterations so far as the same may be applicable.

(*h.*) If the owners decline, or for twenty-four hours after the time when any such alterations are required to be commenced, neglect to comply with such notification, the operators may themselves proceed to execute such alterations in like manner as they might have done if no such statement as aforesaid had been served upon them by the local authority.

(*i.*) All expenses properly incurred by any owners in complying with any notification of any operators under the last preceding sub-sections shall be repaid to them by such operators, and may be recovered summarily before any court of summary jurisdiction who shall have power to determine the amount thereof.

(*j.*) Any owners may, if they think fit, by any statement served by them upon any operators under this section require the operators to give them such security for the repayment to them of any expenses to be incurred by them in executing any alterations as above mentioned, as may be agreed upon between such owners and operators, or in default of agreement as may be determined by arbitration, and where any operators have been so required to give security they shall not be entitled to serve a notification upon the owners requiring them to execute such alterations until such security has been duly given.

Gasworks Clauses Act, 1847, sec 7. E. L. Act, sec. 17.

If the operators make default in complying with any of the requirements or restrictions of this section they shall (in addition to any other compensation which they may be liable to make under the provisions of this order or the principal Act) make full compensation to the owners affected thereby for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence such further sum not exceeding five pounds for every day after the first day during which such default continues, as a court of summary jurisdiction upon complaint made may determine, provided that the operators shall not be subject to any such forfeiture as aforesaid if the court having cognizance of the case are of opinion that the case was one of emergency, and that the operators complied with the requirements of this section so far as was reasonable under the circumstances.

Laying of electric lines, pipes, &c., near those of gas or water company or of undertakers.

16. Whenever the undertakers require to dig or sink any trench for laying down any new electric lines (other than service lines) or other works near to which any pipe belonging to any gas or water company, or any branch or service pipe for the supply of gas or water has been lawfully placed, or where any gas or water company require to dig or sink any trench for laying down any new mains or pipes other than service pipes or other apparatus near to which any electric lines or works of the undertakers have been lawfully placed, the undertakers, or such gas or water company (as the case may be) in this section referred to as "the operators," shall give to such gas or water company or to the undertakers (as the case may be), in this section referred to as "the owners," not more than forty-eight hours and not less than twenty-four hours notice before commencing to dig or sink such trench as aforesaid, and such owners shall be entitled by their officer to superintend the digging or sinking of such trench, and the operators shall conform with such reasonable requirements

as may from time to time be made by the owners or such officer for the protection of every such pipe, electric line, or work, and for securing the same from injury, and they shall also repair any damage that may be done to any such pipe, electric line, or work.

If the operators make default in complying with any of the requirements or restrictions of this section, they shall make full compensation to the owners of any pipe, electric line, or work affected thereby for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues: Provided that the operators shall not be subject to any such penalty if the court having cognizance of the case are of opinion that the case was one of emergency and that operators complied with the requirements and restrictions of this section so far as was reasonable under the circumstances, or that the default in question was due to the fact that the operators were ignorant of the position of the pipe, electric line, or work affected thereby, and that such ignorance was not owing to any negligence on the part of the operators.

For protection of telephone companies, &c.

E. L. Act, sec. 26.

Seven days before commencing to lay down any electric line, or to supply electricity through any electric line in any manner whereby the work of telegraphic or telephonic communication through any wires or lines, may be injuriously affected, the undertakers shall give to the persons for the time being entitled to such wires or lines notice in writing specifying the course, nature, and gauge of such electric lines, and the amount and nature of the current intended to be sent along the same, and the extent to and manner in which, if at all, earth returns are proposed to be used, and the undertakers shall conform with such reasonable requirements as may from time to time be made by such persons as aforesaid for the purpose of preventing the communication through such wires or lines from being injuriously affected as aforesaid.

If any difference arises between any such persons and the undertakers with respect to the reasonableness of any requirements so made, such difference shall be determined by arbitration.

Gasworks Clauses Act, 1847, sec. 7. E. L. Act sec. 15.

Provided that nothing in this section shall apply to repairs or renewals of existing electric lines so long as the character and position thereof is not altered, nor to the laying of connexions

Provisional Order. Chelsea.

with mains where the direction of the electric line so laid down crosses the direction of the said telegraphic or telephonic wires or lines at right angles at the point of shortest distance, and such directions continue the same for a distance of six feet on each side of such point.

If the undertakers make default in complying with any of the requirements or restrictions of this section they shall make full compensation to the persons entitled to any wire or line affected thereby for any loss or damage which they may incur by reason thereof and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding forty shillings for every day after the first day during which such default continues: Provided that the undertakers shall not be subject to any such forfeiture if the court having cognisance of the case are of opinion that the case was one of emergency, and that the undertakers complied with the requirements of this section so far as was reasonable under the circumstances, or that the default in question was due to the fact that the undertakers were ignorant of the position of the wires or lines affected thereby, and that such ignorance was not owing to any negligence on the part of the undertakers.

Exercise of Powers of Undertakers as to breaking up Streets, &c., by Local Authority, &c.

Local authority may give notice of desire to break up streets, &c., on behalf of undertakers. E. L. Act, sec. 3, sub-sec. 9.

17. The local authority and the persons for the time being entitled to work any railway or tramway if they think fit may from time to time give a notice to the undertakers stating that they desire to exercise or discharge all or any part of any of the powers or duties of the undertakers as therein specified in relation to the breaking up, filling in, reinstating, or making good any streets, bridges, sewers, drains, or tunnels, vested in or under the control or management of the local authority or any such railway or tramway (as the case may be).

Every such notice shall be served upon the undertakers, and may from time to time be amended or revoked by another notice similarly served.

Proceedings where local authority give such notice.

18. Where the local authority or the persons for the time being entitled to work any railway or tramway (in this section referred to as "the givers of the notice") have given notice that they desire to exercise or discharge any specified powers and duties of the undertakers as in the last section mentioned, then so long as

such notice remains in force the following provisions shall have effect—

(*a.*) The undertakers shall not be entitled to proceed themselves to exercise or discharge any such specified powers or duties as aforesaid, except where they have required the givers of the notice to exercise or discharge such powers or duties, and the local authority have refused or neglected to comply with such requisition, as hereinafter provided, or in cases of emergency.

(*b.*) In addition to any other notices which they may be required to give under the provisions of this order or the principal Act, the undertakers shall, not more than forty-eight hours and not less than twenty-fours before the exercise or discharge of any such powers or duties so specified as aforesaid is required to commence, serve a requisition upon the givers of the notice stating the time when and the manner in which any such powers or duties are required to be exercised or discharged.

(*c.*) Upon receipt of any such requisition as last aforesaid the givers of the notice may proceed to exercise or discharge, any such powers or duties as required by the undertakers subject to the like restrictions and conditions as the undertakers would themselves be subject to in such exercise or discharge so far as the same may be applicable.

(*d.*) If the givers of the notice decline, or for twenty-four hours after the time when any such exercise or discharge of any powers or duties is by any requisition required to be commenced, neglect to comply with such requisition, the undertakers may themselves proceed to exercise or discharge the powers or duties therein specified in like manner as they might have done if such notice as aforesaid had not been given to them by the givers of the notice.

(*e.*) In any case of emergency the undertakers themselves may proceed to at once exercise or discharge so much of any such specified powers or duties as aforesaid as may be necessary for the actual remedying of any defect from which the emergency arises without serving any requisition on the givers of the notice.

(*f.*) If the undertakers exercise or discharge any such specified powers or duties as aforesaid otherwise than in accordance with the provisions of this section, they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such offence continues.

(*g.*) All expenses properly incurred by the local authority in complying with any requisition of the undertakers, under this section shall be repaid to them by the undertakers, and may be recovered summarily before any court of summary jurisdiction, who shall have power to determine the amount thereof.

E. L. Act, sec. 3, sub-sec. 9.

(*h.*) The givers of the notice may from time to time, if they think fit, require the undertakers to give them such security for the repayment to them of any expenses incurred by them under this section, as may be agreed upon between them and the undertakers, or in default of agreement as may be determined by arbitration. If the undertakers fail to give any such security within seven days after being required to do so or in case of difference after the delivery of the arbitrator's award, they shall not be entitled to serve any further requisition upon such givers of notice requiring them to exercise or discharge any powers or duties under this section, until such security has been duly given.

Provided that nothing in this or the last preceding section shall in any way affect the rights of the undertakers to execute or discharge any powers or duties conferred or imposed upon them by this order or the principal Act, in relation to the execution of any works beyond the actual breaking up, filling in reinstating, or making good any such streets, bridges, sewers, drains, or tunnels, or railway or tramway, as in the last section mentioned.

(*e*) Emergency is always an excuse for breaking up the streets without notice (see Gasworks Clauses Act, 1847, secs 8 and 9).

Compulsory Works.

Mains, &c. to be laid down in certain streets specified in Schedule A. within two years. Clause 5 of this order.

19. The undertakers shall, within a period of *two years* after the commencement of this order, lay down suitable and sufficient distributing mains for the purposes of general supply upon the parallel system, in every street and part of a street specified in

that behalf in Schedule A. to this order and shall thereafter maintain the same. (Electric Lighting Act, sec. 6, subsec. [a]).

20. In addition to the mains specified in the last section, the undertakers shall, at any time after the expiration of the period of *two years* after the commencement of this order, lay down and maintain suitable and sufficient distributing mains for the purposes of general supply upon the parallel system in every street or part of a street within the area included in Schedule A. upon being required to do so in manner by this order provided.

Mains, &c. to be laid down in remainder of area in Schedule A. on requisition.

E. L. Act, sec. 6 (*a*).

All such mains as above mentioned shall be laid down by the undertakers within six months after the service upon them of the requisition in that behalf in accordance with the provisions of this order, or such further time as may in any case be approved of by the Board of Trade.

Clause 66.

21. If the undertakers make default in laying down any mains in accordance with the provisions of the last preceding sections, within the periods prescribed in that behalf respectively the Board of Trade may upon the application of the local authority revoke this order as to the whole or any part of the area of supply, or if the undertakers so desire, may, after having given an opportunity to the local authority to make representations and objections with reference thereto, suffer the same to remain in force in whole or in part, subject to such conditions as they may think fit to impose, and any conditions so imposed shall be binding on and observed by the undertakers, and shall be of the like force and effect in every respect as though they were contained in this order.

If undertakers fail to lay down mains, &c. order may be revoked.

E. L. Act, sec. 6 (*f*).

22. At any time after the date when any addition to the area of supply of any part of the area included in Schedule B. is directed to take effect, the undertakers shall cause suitable and sufficient distributing mains, for the purposes of general supply upon the parallel system, to be laid down in every street or part of a street within the part so added to the area of supply, upon being required to do so in manner by this order provided.

Mains, &c. to be laid down in area included in Schedule B. on requisition.

Clause 6.

All such mains as above mentioned shall be laid down by the undertakers within six months after the service upon them of a requisition in that behalf in accordance with the provisions of this order, or such further time as may in any case be approved of by the Board of Trade.

If the undertakers make default in laying down any distri-

E. L. Act, sec. 6 (*a*).

buting mains in accordance with the provisions of this section, the Board of Trade may upon the application of the local authority revoke this order as to the whole or any part of such addition to the area of supply, or if the undertakers so desire may, after having given an opportunity to the local authority to make representations or objections with reference thereto, suffer the same to remain in force in whole or in part, subject to such conditions as they may think fit to impose, and any conditions so imposed shall be binding on and observed by the undertakers, and shall be of the like force and effect in every respect as though they were contained in this order.

Manner in which requisition is to be made.

E. L. Act, sec. 6 (*b*).

23. Any requisition requiring the undertakers to lay down distributing mains for the purposes of general supply* in any street or part of a street under the last preceding sections may be made by two or more owners or occupiers of premises along such street or part of streets, or, where the local authority has the control and management of the public lamps, in such street or part of a street, by the local authority.

Every such requisition shall be signed by the owners and occupiers making such requisition, or by the local authority, as the case may be, and shall be served upon the undertakers.

Forms of requisitions shall be kept by the undertakers at their office, and a copy shall be supplied to any owner or occupier of premises within the district and to the local authority on applying for the same at the price of one shilling a copy, and any requisition so supplied shall be deemed valid in point of form.

Provisions on requisition by owners or occupiers.

24. Where any such requisition is made by any such owners or occupiers as aforesaid, the undertakers (if they think fit) may, within fourteen days after the service of the requisition upon them, serve a notice on all the persons by whom such requisition is signed, stating that they decline to be bound by such requisition unless such persons or some of them will bind themselves to take a supply of electricity for three years, of such amount in the aggregate (to be specified by the undertakers in such notice) as will at the rates of charge for the time being charged by the undertakers for a supply of electricity from distributing mains to ordinary consumers within the area of supply produce an annual sum (to be specified by the undertakers in such notice) amounting to not less than 20 per centum upon the expense of providing and laying down the required distributing mains and

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* Clause 2 of this order.

any other mains which may be necessary for the purpose of connecting such distributing mains with the nearest available source of supply, and thereupon such requisition shall not be binding on the undertakers unless within fourteen days after the service of such notice on all the persons signing such requisition has been effected, or in case of difference, the delivery of the arbitrators' award, there be tendered to the undertakers an agreement severally executed by such persons or some of them, binding them to take for a period of three years at the least such specified amounts of electricity respectively as will in the aggregate at the rates of charge above specified, produce an annual sum amounting to not less than *twenty* per centum upon the expense of providing and laying down such distributing mains and other mains as above mentioned, nor unless security for the payment to the undertakers of all moneys which may become due to them from such persons under such agreement is offered to the undertakers (if required by them by such notice as aforesaid) within the period limited for the tender of the agreement as aforesaid.

If any difference arises between the undertakers and any persons signing any such requisition as to the reasonableness of the amounts specified by the undertakers in their notice, such difference shall be determined by arbitration.

Provisions on requisition by local authority.

25. Where any such requisition is made by the local authority it shall not be binding on the undertakers unless at the time when such service is effected, or within fourteen days thereafter, there be tendered to the undertakers (if required by them) an agreement executed by the local authority, and binding them to take for a period of three years at the least a supply of electricity for lighting such public lamps in the street or part of a street in respect of which such requisition is made as may be under their management or control.

The effect of secs. 19-25 is to compel the undertakers, within two years, to lay down mains along the streets specified in Schedule A. After the expiration of two years they may at any time be required, either by any two owners or occupiers of a street, or by a local authority having control of the lamps in a street, to lay down mains in any street within the area specified in Schedule A. But in this case the owner, or occupier, or the local authority must enter into an undertaking to use the electricity. Further, after the expiration of two years, the undertakers may be required by the local authority to apply to the Board of Trade to have the area extended to any part of the area specified in schedule B. If they do not so apply, this part may then be removed from their order (clauses 6 and 7). If they do apply, then such order as is fair may be made with regard to the parts of the areas to be added to the area of the undertakers; and with regard to the area so added, the private occupiers and local authority shall then have the same rights to demand a supply as they have within the original area specified in Schedule A.

The security required in the case of these occupiers is such a user of electricity for three years as shall yield a rent equal to twenty per cent. of the cost of the mains.

Where, however, any consumer is within twenty-five yards of a main, (and within the undertakers' area for the time being) he shall always be entitled to a supply, on undertaking to use electricity, so that the rent shall yield twenty per cent. for two years on such part of the cost of the laying down the service mains as falls on the undertakers, (clause 45) that is to say, the cost of laying of service wires to a distance of thirty feet, over land not the property of the consumer.

This is not a very onerous provision for the consumer, as twenty per cent. of the prime cost of laying the mains and service wires, cannot amount to a very large sum, and will consequently not represent a very large use of electricity.

Maps.

Map of area of supply to be made.

26. The undertakers shall forthwith, after commencing to supply electricity under this order, cause a map to be made of the area of supply, on such a scale as may from time to time be prescribed by the local authority with the approval of the Board of Trade, and shall cause to be marked thereon the line of all their then existing mains, service lines, and other underground works and distributing boxes, and shall once in every year correct such map and make such additions thereto as will show the line of all their then existing mains, service lines, and other underground works and distributing boxes.

Deposit and inspection of maps.

27. Every map so made for the undertakers, or a copy thereof, with the date expressed thereon of the last time when it was so corrected, shall be kept by the undertakers at their principal office within the area of supply, and a copy of every such map shall, within one month after such map is made, be served by the undertakers upon the Board of Trade, and upon the Postmaster-General and upon the local authority.

Every copy of the said map as last corrected which may be served upon the local authority shall be kept by them at their office, and shall at all reasonable times be open to the inspection of all applicants, and such applicants may take copies of the same or any part thereof.

The local authority may demand or take from every such applicant as aforesaid such fee not exceeding one shilling for each inspection of such map or copy, and such further fee not exceeding one shilling for each copy of the same, or any part thereof, taken by such applicant, as they may from time to time prescribe.

Penalty on undertakers and persons refusing inspection of maps.

28. If the undertakers fail to comply with any of the requirements of the last preceding section of this order with respect to maps, they shall for every such offence be liable to a penalty not exceeding ten pounds, and to a further penalty not exceeding two pounds for every day after the first day during which such offence continues.

Regulations as to Supply on the Parallel System.

Provisions as to parallel system.

29. The following provisions shall apply to the supply of electricity by the undertakers upon the parallel system:—

Notice of intention to supply through any distributing mains to be given to local authority.

(*a.*) One week at least before commencing to supply electricity through any distributing main, the undertakers shall serve a notice upon the local authority of their intention to commence such supply, and that the said main is ready to be tested.

Undertakers provide constant supply. Pressure in mains during supply

(*b.*) From and after the time when the undertakers commence to supply electricity through any distributing main, they shall maintain in such main a current of electricity sufficient for the use of all the inhabitants within the area of supply, who, as hereinafter provided, may be entitled to demand a supply, and be willing to pay for the same; and such supply shall, except so far as may be otherwise agreed upon from time to time between the local authority and the undertakers, be constantly maintained at such pressure as may be fixed under the provisions of this order; Provided that during the six months after the undertakers first commence to supply electricity under this order, or such longer period as may in any case be approved of by the Board of Trade, the undertakers need not maintain a supply of electricity during the hours between sunrise and sunset in each day; and that, for the purposes of testing or for any other purpose which the Board of Trade may consider necessary for the efficient working of the undertaking, the Board of Trade may from time to time permit the undertakers to discontinue the supply of electricity at such intervals of time and for such periods as the Board of Trade may think expedient.

Pressure in mains during supply.

(*c.*) During the whole of the period when a supply of electricity is required to be maintained by the undertakers in the distributing mains under this order (in this order termed "the hours of supply"), the potential at corresponding points of the positive and negative distributing mains shall differ at each point by a constant difference (in this order termed "the standard pressure"), to be fixed as hereinafter specified: Provided that the undertakers shall be deemed to have complied with the requirements of this sub-section so long as the difference in potential does not at any point vary more than five per cent. from the corresponding standing pressure, unless changes in potential occur so frequently as to cause unsteadiness in the supply.

Limits of standard pressure.

(*d.*) The standard pressure may be different for different points of any main, and with the approval of the local authority for different hours during the period of supply, but it shall in all cases be within the limits following:—

In the case of continuous currents it shall not be less than thirty volts or more than two hundred volts, and
In the case of alternating currents it shall not be less than fifty volts or more than one hundred volts.

Provided that such limits may from time to time be varied by the Board of Trade either generally or in respect of individual cases.

Fixing of standard pressure.

(*e.*) The "standard pressure" shall be fixed by the undertakers for every main, and notice of the amount of such standard pressure shall be given to the local authority before the undertakers commence to supply electricity to consumers through such main, and shall not be altered except by permission of the local authority, and upon such terms and conditions as the local authority may impose, and after public notice has been given during a period of *one month*, in such manner as the local authority may require of the intention of the undertakers to apply for permission to alter the same.

(*f.*) The number of alternations per minute of alternating currents shall not during the hours of supply be less than six hundred, or such other number as may from time to time be fixed by the undertakers and sanctioned by the local authority.

Number of alternations in alternating currents.

(*g.*) The supply of electricity upon any premises shall (except by agreement) be given at two poles situated thereon at a safe and convenient distance from one another in connexion respectively with the positive and negative mains. and the undertakers shall be responsible for the maintenance of such poles and any other lines, fittings, and apparatus belonging to the undertakers, or under their control upon such premises in a fit and proper condition for supplying electricity, but the undertakers shall not be in any way responsible for any defects in the construction of any electric lines or fittings within such premises, whether for the utilisation of the electricity supplied or otherwise where such electric lines or fittings have not been supplied by them, nor for any neglect in the maintenance of any such electric lines or fittings where they do not belong to the undertakers, or are not under their control.

Supply to be given at two poles on consumer's premises.

(*h.*) The resistance of the service lines by which the supply is given to any consumer shall not, except by agreement, be greater than would cause the difference of potential at the positive and negative poles in any customer's premises to be less than the corresponding difference of potential at the point of junction of the mains and the service lines by which he is supplied by more than *two and a half* per centum of the corresponding standard pressure when the maximum current with which he is entitled to be supplied by the undertakers under this order is passing through such service lines.

Pressure at the consumer's premises.

29. (*c.*) This does not of course mean that the difference of potential between any two arbitrarily selected points shall always be the same as that between any two others; such a provision would be an impossibility. It rather means that the potential of different parts of the mains shall be kept in a constant condition. Every point in the circuit must have a corresponding point somewhere, such that the difference between them amounts to the standard pressure and by "corresponding points" I presume is meant that when any one point is taken, the point in the main "corresponding" to it shall be that point which has the greatest difference of potential. Great skill and care will be necessary in the proper arrangement of the conducting mains and wires.

Provisional Order. Chelsea.

The maximum standard pressure for continuous currents is fixed at 200 volts, and for alternating, 100 volts. These figures have been taken probably for safety. It is the *interruptions* of currents that seem most to affect the human body, hence alternating currents are not to exceed 100 volts, an amount quite enough to be somewhat unpleasant. What are here called "continuous currents" are not really continuous, from ordinary dynamos, but are intermittent, as represented thus, — — — — — — and their effect upon the human system generally is diminished in proportion as they approach continuity thus —————— this latter current at the same potential, appears to be much less felt than the former, although the total energy of the latter would (at the same potential), be greater than the former.

An *absolutely* continuous current of very considerable electromotive force would give a severe shock on making the contact, but would afterwards be hardly felt, but I believe but few experiments have as yet been made upon this subject. If certain consumers continue to tamper with the lamps, as I have known them to do, we shall probably be shortly in a position to judge more accurately of the current necessary to injure the human body.

(*f.*) This is a low number of alternations; less would cause the lamps to "wink" visibly. With a greater number the continuity of impression on the retina of the eye prevents the alternation being observed. A sharp turn of the head or the rapid motion of a mirror will, however, make the light appear like a row of stars.

(*h.*) This regulation fixes the size of the service lines for each house. If the lamps in the house are fixed on the parallel system, the total resistance will be small, and equal

$$\frac{\text{Resistance of each lamp}}{\text{No. of lamps.}} + \text{resistance of wires in the house.}$$

If we had (say) forty incandescent lamps of the Swan pattern, the total resistance when the lamps were burning would be about an ohm. Hence the resistance of the service lines could not under the above sections be greater than 2½ per cent. of an ohm, equal ·025 ohm. If the wires were (say) fifty feet long each, this would require them to be made about ·2 inches in diameter—but practically they would be bigger than this, though it is to be noticed that the second mode of charging for the electricity (clause 49) causes the consumer to pay as for the *energy* given at the junctions of the service wires with the mains, hence there will be no inducement to the undertakers to supply larger service wires than they are compelled to by law. For with the second method of charging, any energy lost in heating the service wires will be at the expense of the consumer.

Testing.

30. The local authority, so long as they are not themselves the undertakers for the purposes of this order, shall from time to time appoint, or appoint and keep appointed, one or more competent and impartial persons to be electric inspectors for the purpose of inspecting electric lines and works, and of certifying meters under this order.

Appointment of electric inspectors by local authority. E. L. Act, sec. 6 (*e*).

31. If no electric inspector is appointed by the local authority, or if the inspection of electric lines and works is imperfectly attended to by the local authority, or if the local authority themselves become the undertakers for the purposes of this order, a court of summary jurisdiction, on the application of any person supplied with electricity by the undertakers within the area of supply, may from time to time appoint or may appoint and keep appointed one or more competent and impartial persons to be electric inspectors for the purposes aforesaid.

Appointment of electric inspectors by a court of summary jurisdiction in certain cases.

32. The local authority shall pay to every electric inspector appointed under this order such reasonable remuneration (if any) as may from time to time be determined by the authority by whom he is appointed, and such remuneration may be in addition to or in substitution for any fees which are directed to be paid to electric inspectors for services rendered by them under this order, as may be settled by the authority by whom such remuneration is determined: Provided that where any such remuneration is settled to be in substitution for such fees as aforesaid, such fees shall, in lieu of being paid to such electric inspector for his own use, be due and paid to him on behalf and for the use of the local authority, and shall be carried by them to the credit of the local rate.

Remuneration of electric inspectors.

33. Every electric inspector, if and when required to do so by the authority by whom he is appointed, shall from time to time test for insulation and conductivity any portion of any main of the undertakers within the area of supply through which electricity is supplied by them, or through which they have given notice to the local authority, as by this order provided, that they intend to commence supplying electricity: Provided that such testings shall not be made in regard to any particular portion of a main oftener than once in any three months, unless in pursuance of a special order in that behalf made by the Board of Trade.

Testing of mains.

34. Every electric inspector, if and when required to do so by any person supplied with electricity by the undertakers, shall from time to time test the insulation and conductivity of the service lines by which such electricity is supplied.

Testing of service lines.

Mode of testing.

35. Notice shall be given to the undertakers before the commencement of any testing by an electric inspector, and such testing shall be carried out at such suitable hours as, in the opinion of such inspector, will least interfere with the supply of electricity by the undertakers, and in such manner as such inspector may think expedient, but except under the provisions of a special order in that behalf made by the Board of Trade, he shall not be entitled to have access to or interfere with the mains of the undertakers at any points other than those at which the undertakers have reserved for themselves access to the said mains: Provided that the undertakers shall not be held responsible for any interruption in the supply of electricity which may be occasioned by or required by such inspector for the purpose of any such testing as aforesaid.

Report of results of testing.

36. Every electric inspector shall, on the day immediately following that on which any testing has been completed by him under this order, make and deliver a report of the results of his testing to the authority or person by whom he was required to make such testing, and to the undertakers, and such report shall be receivable in evidence.

Expenses of testing.

37. Where the report of any electric inspector shows as the result of any testing that the undertakers were in default, the expenses of such testing, including such reasonable fees to the electric inspector as may from time to time be prescribed in that behalf by the local authority, with the approval of the Board of Trade, shall be paid by the undertakers; but if such report shows that the undertakers were not in default, such expenses shall be paid, in case of mains where the electric inspector is appointed by any local authority, by such local authority, and where such electric inspector was appointed by a court of summary jurisdiction, then by the local authority, or such company or person as the court may direct, and in case of service lines by the person requiring the electric inspector to make such testing.

Provided, that if any person is dissatisfied with any report of any electric inspector under the last preceding sections, they may appeal to the Board of Trade against such report, and thereupon the Board of Trade shall inquire into and decide upon the matter of any such appeal, and their decision shall be final and binding on all parties.

Local authority to establish testing places and keep instruments.

38. The local authority may, at such places within a reasonable distance from any distributing main as they think fit, establish at their own cost such reasonable number of testing stations as they shall deem to be sufficient for testing the supply

of electricity by the undertakers through such main, and may place thereat proper and suitable instruments, of a pattern to be approved by the Board of Trade, for the purpose of testing such supply, and they may require the undertakers to connect such stations by means of proper and sufficient service lines with such main at the expense of the undertakers, and to supply electricity thereto for the purpose of such testing free of charge.

If any dispute arise between the local authority and the undertakers as to whether the number of such testing stations and the distance from the main at which they are established is reasonable or excessive, or to the performance by the undertakers of their duties under this section, such dispute shall be determined by arbitration.

Readings of instruments to be taken.

39. The local authority shall keep all instruments used by them for the purpose of testing any supply of electricity by the undertakers in efficient working order, and any electric inspector appointed under this order may from time to time examine and record the readings of such instruments at such times and in such manner as he may be directed by the authority by whom he is appointed, and any readings so recorded shall be receivable in evidence.

Undertakers may test instruments of local authority.

40. The undertakers shall have the right to have access at all reasonable times to such instruments for the sake of testing the same and ascertaining if the same are in order, and may require the local authority forthwith to have the same put in order in case they are not so.

Undertakers to keep instruments.

41. The undertakers shall also set up and keep in efficient working order, upon all premises from which they supply electricity by any distributing mains or electric lines, suitable and proper instruments, of such pattern and construction as may be from time to time approved of or prescribed by the Board of Trade, for measuring thereof the difference of potential between such mains and electric lines and the earth, and the current passing along such mains and electric lines, and shall record and keep recorded the readings of these instruments taken at intervals of not more than *one hour* during the time that electricity is being supplied thereto from such premises, and any readings so recorded shall be receivable in evidence.

Electric inspector may test undertakers instruments.

42. Any electric inspector appointed under this order, shall have the right to have access at all reasonable hours to the instruments mentioned in the last preceding section, for the purpose of testing the same and ascertaining if the same are in order, and in case

the same are not in order he may require the undertakers forthwith to have the same put in order.

Representation of undertakers at testings.

43. The undertakers may, if they think fit, on each occasion of the testing of any main or service line, or the testing or inspection of any instruments of the undertakers by the electric inspector, be represented by some officer or other agent, but such officer or agent shall not interfere in the testing or inspection.

Undertakers to give facilities for testing.

44. The undertakers shall afford all facilities for the proper execution of this order with respect to testing, and shall comply with all the requirements of this order in that behalf; and in case the undertakers may make default in complying with any of the provisions of this section they shall be liable to a penalty not exceeding five pounds, and in the case of a continuing offence to a further penalty not exceeding one pound for every day after the first day during which such offence continues.

By sec. 24 of the Electric Lighting Act, the undertakers have power to enter premises at all reasonable times to ascertain the amount consumed, &c.

Supply.

Undertakers to furnish sufficient supply of electricity to owners and occupiers within the limits of the special Act

45. The undertakers shall, upon being required so to do by the owner or occupier of any premises situate within twenty-five yards from any distributing main of the undertakers, give and continue to give a supply of electricity for such premises subject to the provisions of this order, and they shall furnish and lay any electric lines that may be necessary for the purpose of supplying the maximum current with which any such owner or occupier may be entitled to be supplied under this order, subject to the conditions following; (that is to say,)

The cost of so much of any electric line for the supply of electricity to any owner or occupier as may be laid upon the property of such owner or in the possession of such occupier, and of so much of any such electric line as may be laid for a greater distance than thirty feet from any distributing main of the undertakers, although not on such property, shall be defrayed by such owner or occupier.

Every owner or occupier of premises requiring a supply of electricity shall—

Serve a notice upon the undertakers at their office, specifying the premises in respect of which such supply is required and the maximum current required to be supplied, and the

Provisional Order. Chelsea.

day (not being an earlier day than a reasonable time after the date of the service of such notice) upon which such supply is required to commence:

Enter into a written contract with the undertakers (if required by them so to do) to continue to receive and pay for a supply of electricity for a period of at least two years, of such an amount that the rent payable for the same, at the rate of charge for the time being charged by the undertakers for a supply of electricity to ordinary consumers within the area of supply, shall not be less than twenty pounds per centum per annum on the outlay incurred by the undertakers in providing any electric line to be provided by them for the purpose of such supply, and give to the undertakers (if required by them so to do) security for the payment to them of all moneys which may become due to them by such owner or occupier in respect of any electric lines to be furnished by the undertakers, and in respect of electricity to be supplied by them.

Provided always, that the undertakers may, after they have given a supply of electricity for any premises, by notice in writing, require the owner or occupier of such premises, within seven days after the date of the service of such notice, to give to them security for the payment of all moneys which may from time to time become due to them in respect of such supply, in case such owner or occupier has not already given such security, or in case any security given has become invalid or is insufficient; and in case any such owner or occupier fail to comply with the terms of such notice, the undertakers may, if they think fit, discontinue to supply electricity for such premises so long as such failure continues.

It is to be presumed that this 25 yards is to be measured in a straight line. This might in cities involve the laying of a main for many hundred yards round, as the premises might be directly inaccessible along a public road and the intervening owners might object. This, however, is of no great hardship on the undertakers, for they are not obliged to lay more than 30 feet of service mains at their own expense. The rest falls on the person demanding the supply. Owing to the laws governing the distribution of electricity where the lamps are arranged in the houses in parellel arc, a distant person requiring a supply of electricity would want almost a distributing main-cable to supply it; otherwise the waste would be enormous, and, moreover, the requirements of clause 29 (*g*) would not be fulfilled. It does not here appear whose property the wire would be that was paid for by the consumer. The limits of

25 yards for private consumers and 50 yards for public lamps are the same as in the case of gas companies. (See note to sec. 29 of the Electric Lighting Act, 1882.)

Maximum current.

46. The maximum current with which any such consumer, as in the last section mentioned, shall be entitled to be supplied shall be of such amount as he may from time to time require to be supplied with, not exceeding what may be reasonably anticipated as the maximum consumption on his premises: Provided that where any consumer has required the undertakers to supply him with a maximum current of any specified amount, he shall not be entitled to alter that maximum except upon one month's notice to the undertakers, and any expenses incurred by the undertakers in respect of the service lines, by which electricity is supplied to the premises of such consumer, or any electric lines, fittings, or apparatus of the undertakers upon such premises, consequent upon such alteration, shall be paid by him to the undertakers, and may be recovered summarily as a civil debt.

If any difference arises between any such owner or occupier and the undertakers as to what may be reasonably anticipated as the consumption on his premises, such difference shall be determined by arbitration.

As the consumer is bound to pay for any alterations required by him in the size of the conducting wires, unless the undertakers charge in the third method by maximum quantity, the consumer will do well to demand the largest maximum he can get, and so secure large mains, which will cause little waste and be always sufficient, subject, however, to his liabilities under clause 24.

Supply of electricity to public lamps.

47. The undertakers shall supply electricity to any public lamps within the distance of fifty yards from any of the distributing mains of the undertakers in such quantities as the local authority may from time to time require to be supplied.

In the case of incandescent lamps this would be a very onerous liability, for the waste at long distances is very great, but by clause 52 this, no doubt, would be allowed for.

Penalty for failure to supply.

48. Whenever the undertakers make default in giving a supply of electricity of such pressure and during such hours as are by this order required to any owner or occupier of premises to whom they may be and are required to supply electricity under this order, they shall be liable to a penalty not exceeding forty shillings in respect of every such default for each day upon which any such default occurs.

Whenever the undertakers make default in supplying electricity of such pressure and during such hours as are by this order required to all or any of the public lamps to which they may be and are required to supply electricity under this order, they shall be liable to a penalty not exceeding forty shillings in respect of every such default for each such lamp, and for each day upon which any such default occurs.

Provided that the penalties to be inflicted on the undertakers under this section shall in no case exceed in the aggregate the sum of one hundred pounds in respect of any defaults in supplying private consumers, and one hundred pounds in respect of any defaults in supplying public lamps for any one day, and provided also that in no case shall any penalty be inflicted in respect of any default, if the court, having cognizance of the case, are of opinion that such default was caused by inevitable accident, or by force majeure, or was of so slight or unimportant a character as not materially to affect the value of the supply.

Price.

Methods of charging.

49. The undertakers may charge for electricity supplied by them from any distributing main to any ordinary consumer (otherwise than by agreement)—

(1.) By the quantity of energy contained in such supply; or,

(2.) By the actual quantity of electricity so supplied; or,

unless the Board of Trade from time to time otherwise direct,

(3.) By the number of hours during which the supply of electricity is actually used by such consumer, and the maximum current with which he is for the time being entitled to be supplied:

Provided that before commencing to supply electricity through any distributing main for the purposes of general supply, the undertakers shall give notice to the local authority by what method they propose to charge for electricity supplied through such main; and, where the undertakers have given any such notice, they shall not be entitled to change such method of charging except after one month's notice of such change has been given by them to the local authority and to every consumer of electricity who is supplied by them from such main.

There are three modes of charge here provided, which are further explained under the heads of Meters and Cost of Electric Lighting in the Notes on Electricity, Part II. The first method is by the "quantity of energy contained in the supply."

Provisional Order. Chelsea.

The energy of a quantity of electricity is found by multiplying the quantity into the pressure, or electromotive force. This is its work-doing efficiency. The power of a current, or its work-doing capacity per second, is found by multiplying the current strength into the electromotive force. The light-giving capacity of a current is dependent on its power, the total light given is therefore dependent on the energy of the quantity of electricity which has passed. Theoretically this is the best way of measuring electricity, and the fairest, for the cost of producing electricity is proportional also to the energy developed. Unfortunately it is difficult accurately to measure the total energy of a quantity of electricity, and no meter that has as yet been designed is entirely satisfactory.

The second method is to measure the amount of the current. As the electromotive force is known, and ought to be constant, the energy is also determined. The electromotive force, however, which is to be the guide, is not the electromotive force at the terminals of the house, but those at the junctions of the service lines with the main (Schedule C. sec. 2), which is about 2½ per cent. less (clause 29 [*g*].) So that the consumer will pay for rather more than he really receives.

The third method is that most likely to be adopted at first; but it has several drawbacks. For suppose that a consumer has requested a maximum current of 65 ampères at 60 volts, E.M.F., that is, enough for some fifty 20-candle Swan lamps. If he then puts on another half-dozen lamps, who is to discover it, and stop him? It is true that an ammeter may be fixed to his house, but it will be impossible always to be inspecting it. And no doubt a tell-tale might be fixed to the ammeter, such as a loose index-hand to register the maximum current, and indicate any excess over the proper quantity; but who is to say whether an indication of an excess is the result of systematic user or a mere accidental short-circuiting? Such a consumer having applied for a 65-ampère current might continuously use 80 ampères without any one being the wiser. Nor would such a user always be done fraudulently. A *bonâ fide* change of lamps might bring it about. Again, if a consumer were by negligence or design to short-circuit any part of his system, this would cause an enormous sudden accession of current to him, and dim most of the lamps in the neighbourhood. This may be prevented by the use of the fusible. For the instant the current became abnormally strong the plug would melt and cut off the supply, which could only be restored by the undertakers from the outside. As, however, the limits of these plugs will be greater than the normal current required (clause 64 *f*.), the consumer might habitually indulge in an excess over that he was paying for, nor is it clear how he could be prevented from doing so.

Until the measurement system is perfected it seems probable that consumers will not be allowed to tamper with their lights, but must work them according to some regular system. It is one of the great difficulties of electricity that sudden changes in one house may effect all the neighbouring consumers, whereas with gas this is not the case, nor is it possible for a gas consumer to affect the supply of his neighbours except wilfully, as by blowing large quantities of air into his pipes and thence into the mains.

Shops, clubs, hotels, and public institutions which burn lights during regular hours, can no doubt be supplied on the system of paying by the hour, but for private use it will present great difficulties, especially in view of section 18 of the Electric Lighting Act, which prohibits the undertakers from controlling or interfering with the manner in which the electricity is used by the consumer.

Maximum prices.

50. The prices to be charged by the undertakers for electricity supplied by them shall not exceed those stated in that behalf in Schedule C. in the first, second, and third sections thereof respectively.

Other charges by agreement.

51. Subject to the provisions of this order, and of the principal Act, and to the right of the consumer to require that he shall be charged according to some one or other of the methods abovementioned in cases where he is entitled to require a supply, the undertakers may make any agreement with a consumer as to the price to be charged for electricity, and the mode in which such charges are to be ascertained, and may charge accordingly.

Price to public lamps.

52. The price to be charged by the undertakers and to be paid to them for all electricity supplied to the public lamps and the mode in which such charges shall be ascertained, shall be settled by agreement between the local authority and the undertakers, and in case of difference, by arbitration, regard being had to the circumstances of the case and the distributing or other mains (if any) which may have to be laid for the purpose and the prices charged to ordinary consumers in the district.

Meters.

Meters to be used except by agreement.

53. The energy contained in any supply of electricity by the undertakers to any ordinary consumer under this order, or the quantity of electricity so supplied, or the duration of such supply (according to the method by which the undertakers elect to charge), in this order referred to as "the value of the supply," shall, except as otherwise agreed between such consumer and the undertakers, be ascertained by means of an appropriate meter duly certified under the provisions of this order.

As to the various kinds of meters, see Part II. A perfect electric meter is still to be designed. A meter for charges of the third kind (clause 49) could easily be constructed, by causing a detent to catch the balance-wheel of a small clock when the current was not passing, and to rise by means of an electro-magnet, and free it when the current began, to flow, on the principle of an ordinary stop-watch. In such a clock the face would be divided into units, tens, hundreds, and thousands, and the hands by suitable wheelwork would be made to go very slowly. When the current increased beyond a fixed point, a second detent might easily be contrived to throw a wheel into gear and increase the rate of motion.

The defect in the third method of charging is, that the consumer has not the advantage of a graduated supply, he must always pay for "all or none."

Meter to be certified.

54. A meter shall be considered to be duly certified under the provisions of this order if it be certified by an electric inspector appointed under this Act to be of some construction and pattern and to have been fixed and to have been connected with the service lines in some manner approved of by the Board of Trade, and to be a correct meter; and every such meter is in this order referred to as a "certified meter": Provided that, where any alteration is made in any certified meter, or where any such meter is unfixed or disconnected from the service lines, such meter shall cease to be a certified meter unless and until it be again certified as a certified meter under the provisions of this order.

Fees for certifying meters.

55. Every electric inspector who may be required by the undertakers or by any consumer to examine any meter for the purpose of certifying the same as a certified meter under the provisions of this order shall be entitled to demand from the undertakers or consumer so requiring him and to be paid such fees as may from time to time be determined in that behalf by the local authority with the approval of the Board of Trade before commencing such examination, and every electric inspector shall, upon being required so to do by the undertakers or any such consumer as aforesaid, examine any meter situate within the district for which he is appointed if such fees are offered to him as aforesaid, and shall certify the same as a certified meter if he considers it entitled to be so certified.

Undertakers to supply meters if required to do so.

56. Where the value of the supply of electricity to any consumer by the undertakers is under this order required to be ascertained by means of an appropriate meter, the undertakers shall, if required so to do by such consumer, supply him with an appropriate meter, and shall if required so to do, fix the same upon the premises of the consumer and connect the service lines therewith, and procure such meter to be duly certified under the provisions of this order, and for such purposes may authorise and empower any officer or person and any electric inspector to enter upon such premises and execute all necessary works and do all necessary acts; provided that previously to supplying any such meter the undertakers may require such consumer to pay to them

a reasonable sum in respect of the price of such meter, or to give security therefore if he desires to purchase the same, or to enter into an agreement for the hire of such meter as hereinafter provided if he desires to hire such meter, and also to pay to them a reasonable sum in respect of the expenses of fixing such meter and connecting it with the service lines and procuring the same to be certified under this order; if any difference arises between the undertakers and any consumer under this section such difference shall be determined by arbitration.

Meters not to be connected or disconnected without notice.

57. No consumer shall connect any meter used under this order for ascertaining the value of any supply of electricity to him with any electric line through which electricity is supplied by the undertakers, or disconnect any such meter from any such electric lines unless he has given to the undertakers not less than forty-eight hours' notice in writing of his intention so to do, and if any person acts in contravention of this section he shall be liable for each offence to a penalty not exceeding forty shillings.

Consumer to keep his meter in proper order.

58. Every consumer of electricity supplied by the undertakers shall at all times, at his own expense, keep all meters belonging to him, whereby the value of any supply of electricity to him by the undertakers is under this order to be ascertained, in proper order for correctly registering such value, and in default of his so doing the undertakers may cease to supply electricity through such meter.

E. L. Act, sec. 24.

The undertakers shall have access to and be at liberty to take off, remove, test, inspect, and replace any such meter at all reasonable times, provided that all reasonable expenses of and incident to any such taking off, removing, testing, inspecting, and replacing, and the procuring such meter to be again duly certified where such re-certifying is thereby rendered necessary shall, if the meter be found to be not in proper order, be paid by the consumer, but if the same be in proper order, all expenses connected therewith shall be paid by the undertakers.

Power to the undertakers to let meters. Gasworks Clauses Act, 1847, sec. 14.

59. The undertakers may let for hire any meter for ascertaining the value of the supply of electricity by them to any consumer, and any fittings thereto, for such remuneration in money, and on such terms with respect to the repair of such meter and fittings, and for securing the safety and return to the undertakers of such meter, as may be agreed upon between the hirer and the undertakers, and such remuneration shall be recoverable by the undertakers summarily as a civil debt.

Undertakers to keep meter let for hire in repair.

60. The undertakers shall at all times, at their own expense, keep all meters let for hire by them to any consumer, whereby

the value of the supply of electricity by them to such consumer is ascertained, in proper order for correctly registering such value, and in default of their so doing the consumer shall not be liable to pay rent for the same during such time as such default continues. The undertakers shall, for the purposes aforesaid, have access to and be at liberty to remove, test, inspect, and replace any such meter at all reasonable times: Provided that the expense of procuring any such meter to be again duly certified where such re-certifying is thereby rendered necessary shall be paid by the undertakers.

Differences as to correctness of meter to be settled by inspector.

61. If any difference arises between any consumer and the undertakers as to whether any meter whereby the value of any supply of electricity to such consumer by the undertakers is ascertained (whether belonging to such consumer or the undertakers) is or is not in proper order for correctly registering such value, or as to whether such value has been correctly registered in any case by any meter, such difference shall be determined upon the application of either party by an electric inspector, or where the local authority are the consumers, by an inspector to be appointed by the Board of Trade, who shall also order by which of the parties the costs of the proceedings before him shall be paid, and the decision of such inspector shall be final and binding on all parties. Subject as aforesaid, the register of the meter shall be conclusive evidence in the absence of fraud of the value of any supply of electricity by the undertakers to any consumer.

Undertakers to pay expenses of providing new meters where method of charge altered.

62. Where any consumer who is supplied with electricity by the undertakers from any distributing main is provided with a certified meter for the purpose of ascertaining the value of the supply, and the undertakers change the method of charging for electricity supplied by them from such main the undertakers shall pay to such consumer the reasonable expenses to which he may be put in providing a new meter for the purpose of ascertaining the value of the supply of electricity to him according to such new method of charging, and such expenses may be recovered by the consumer from the undertakers summarily as a civil debt.

Undertakers may place meters to measure supply or to check measurement thereof.

63. In addition to any meter which may be placed upon the premises of any consumer to ascertain the value of the supply of electricity to him as between himself and the undertakers, the undertakers may from time to time place upon his premises such meter or other apparatus as they may desire for the purpose of ascertaining or regulating either the amount of electricity or

energy supplied to such consumer, or the number of hours during which such supply is given, or the maximum amount of such supply, or any other quantity or time connected therewith: Provided that such meter shall be of some construction and pattern and shall be fixed and connected with the service lines in some manner approved of by the Board of Trade, and shall be supplied and maintained entirely at the cost of the undertakers, and shall not, except by agreement, be placed otherwise than between the mains of the undertakers and the poles on the consumer's premises at which the supply is given.

This is an important section. If the third method of charge be adopted, some form of current regulator will probably be required, designed so as to admit no more than the maximum current. One scheme upon which such a regulator might be designed is to cause the current to pass through a conducting liquid, and then throttle the area of this conductor at some point by means of an apparatus worked by an electro-magnet, round which the current was passing. Thus like a governor of an engine, this machine would, when the current became too strong, increase the resistance at some point, so as to reduce it, and with this system no great waste of energy would take place. Several regulators have been designed and patented.

Regulations as to Safety.

Regulations to be observed by undertakers.

64. The following regulations shall be observed in relation to the supply of electricity under this order:—

(*a.*) All mains and service lines, so far as they lay in or under streets and public places (otherwise than in distributing boxes or stations), shall be of a pattern to be approved of by the Board of Trade, and shall be covered with thoroughly waterproof covering and be contained in pipes or cases of sufficient strength to protect them from injury, and due precautions shall be taken to prevent any insulating material which may be used being rendered plastic or being otherwise injured by the action of external heat.

(*b.*) All mains or service lines shall be well and sufficiently insulated with some material affording an insulation of a durable character, to be approved of by the Board of Trade, and all parts of service lines shall be so secured that they shall not be liable to be brought into contact with metallic masses upon accidental abrasion of the insulation.

(*c.*) No conductor in any part of any circuit shall be connected with earth unless such connexion is sanctioned by the

Provisional Order. Chelsea.

Board of Trade by any regulations to be hereafter made under the provisions of the principal Act.

(*d.*) The current through any conductor used as a service line shall not exceed one thousand *ampères*, if such current exceeds ten ampères, or two thousand ampères, if such current is less than ten ampères, per square inch of section of a pure copper wire of conductivity equal to that of such conductor; provided that when the insulation employed is such that it would become plastic at a temperature of 120 deg. Fahrenheit, only three fourths of the abovementioned currents shall be allowed.

(*e.*) The supply of electricity to any premises shall be capable of being turned off at some point outside such premises.

(*f.*) In each conductor of each service line shall be inserted a safety fuse or other safety connexion of a pattern to be approved by the Board of Trade. Such fuse or connexion shall be situated in a distributing box or at some other point in the service line which is easily accessible, and shall be of such a nature as to cut off the supply when the current through such conductor exceeds by more than *fifty per centum* (or such other smaller proportion as the undertakers may think fit) the maximum current which such service line is extended to supply.

(*g.*) The positive and negative poles of any service lines upon the premises of the consumer shall be at a distance of not less than *three* inches, and the terminals of any joint which may be made in any portion of any service line which may be upon the premises of any consumer between the point at which it enters upon the said premises and the said poles shall be of some construction and pattern approved of by the Board of Trade.

(*h.*) Where the maximum current given to any consumer by any service lines exceeds fifty ampères, the supply shall be divided and given at more than one pair of poles, so that the maximum current at each pair of poles shall not exceed fifty ampères, except in such cases and under such conditions as may be approved of by the Board of Trade.

(*i.*) Where the difference of potential between any point of any main or electric line used by the undertakers and the earth, or between such point and any other point upon the same circuit exceeds two hundred volts, such precaution shall be taken by the undertakers as may from time to time be prescribed by the Board of Trade by any regulations to be made by them under the provisions of the principal Act, to prevent such main or electric line becoming electrically connected with or leaking into any main or electric line through which electricity passes at a different potential.

(*j.*) Where the difference of potential between any point of any charging main and the earth, or between such point and any other point upon the same circuit exceeds two hundred volts, all distributing mains connected therewith shall be fitted with such appliances and apparatus, of such pattern and construction as may be from time to time prescribed or approved of by the Board of Trade, for the purpose of ensuring that such mains shall be effectually disconnected and kept disconnected from such batteries during the hours of charging.

(*k.*) No portion of any electric line which may be placed by the undertakers above ground, and which is not enclosed within any distributing box or building, shall be at a potential differing from that of the earth by more than two hundred volts.

(*l.*) Where any portions of any electric lines belonging to the undertakers are exposed in such a position as to be liable to be struck by lightning, they shall be efficiently protected by lightning dischargers, of such pattern and construction as may be from time to time prescribed or approved by the Board of Trade.

(*m.*) The difference of potential at corresponding points of the positive and negative conductors used as distributing mains or service lines, shall not at any time exceed *two hundred* volts in the case of continuous currents, and one hundred volts in the case of alternating currents (the difference of potential in the case of alternating currents being taken as equal to the constant difference of potential which would in the case of continuous currents produce the same mean effect), and no portion of any such conductor shall be at a potential differing from that of the earth by more than such quantity.

(*n.*) The difference of potential at any two points of a charging main shall not exceed *four thousand* volts, and no portion of any such main shall be at a potential differing from that of the earth by more than such quantity.

Provisional Order. Chelsea. E. L. Act. sec. 5, B. of T. Arb. Act, secs. 2, 3.

(*o.*) The Board of Trade may at any time direct an inquiry to be made into the condition of any mains, electric lines, or works of the undertakers if they consider it expedient to do so in the interest of the public safety, and for such purpose they may order any such mains, electric lines, or works to be tested in such manner as they may think expedient.

E. L. Act, sec. 6.

Provided always, that if the undertakers at any time desire to supply electricity by agreement, at a high tension for the purpose of arc lighting or for any other purpose, the Board of Trade, if they think fit, may relieve the undertakers from all or any of the obligations by this section imposed upon them, and may substitute such other regulations to be observed by the undertakers in relation to such supply as they may think expedient; and all regulations so substituted shall be observed by the undertakers, and shall, for all purposes of enforcement or otherwise, be deemed to have been inserted in this section in lieu of the regulations for which the same are substituted.

(*a.*) The waterproof covering is to prevent the damp from penetrating to the cores and causing leakage.

(*c.*) The permission to use earth currents would greatly diminish the cost of laying the mains, and the limits of safety (*m*) are so low as to obviate all danger from earth currents.

(*d.*) A current of 1000 ampères flowing through a round copper wire, one square inch section, would warm it perceptibly, but is quite safe. The smaller the wire becomes the greater is its cooling surface in proportion to its sectional area. Thus a round conducting wire of one square inch section would have a cooling surface of 3.45 square inches per inch of length. But a wire of half a square inch section would have a cooling surface of 2.5 square inches per inch of length, that is half as much again as the other in proportion to its conducting power. Therefore the bigger that round wires are made the smaller must be the proportion of current allowed to pass through them. For this reason very large cables might be made in flat strips or woven bands of copper presenting a large cooling surface in proportion to their conductivity, though of course in such cases the insulation would be more expensive.

(*f.*) This provision as to safety plugs is very important. For suppose that through accident or design some consumer were to short-circuit his wires, as could easily be done by joining the terminals by a thick piece of metal, such as a kitchen-poker. Instantly the current through them would be enormously increased, and all the adjoining lamps would become dim, because so easy a channel would have been suddenly offered to the electricity that it would nearly desert all others. The service wires to the house would then be probably melted. To prevent these contingencies the safety plug is inserted, of such nature that when the current becomes too strong, the safety fuze parts, and breaks it.

(*j.*, *n.*) These provisions are to meet the case of storage batteries (see the definition of a "charging main," clause 2).

Notices, &c.

65. Notices, orders, and other documents under this order may be in writing or in print, or partly in writing and partly in print; and where any notice, order, or document requires authentication by the local authority, the signature thereof by the clerk or surveyor to the local authority shall be sufficient authentication. **Notices, &c. may be printed or written.**

66. Any notice, order, or document required or authorized to be served upon any body or person, under this order or the principal Act, may be served by the same being addressed to such body or person, and being left at or transmitted through the post to the following addresses respectively:— **Service of notices, &c.**

(*a.*) In the case of the Board of Trade, the office of the Board of Trade;

(*b.*) In the case of the Postmaster-General, the General Post Office;

(*c.*) In the case of the local authority, the office of the local authority;

(*d.*) In the case of the undertakers or any other company having a registered office, the registered office of the undertakers of such company;

(*e.*) In the case of a company having an office or offices, but no registered office, any such office;

(*f.*) In the case of any other person, the usual or last known place of abode of such person.

Where any notice is served by post it shall be deemed to have been served at the time when the letter containing the notice would be delivered in the ordinary course of post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post.

A notice, order, or document, by this order required or authorized to be served on the owner or occupier of any premises, shall be deemed to be properly addressed if addressed by the description of the "owner" or "occupier" of the premises (naming them), without further name or description.

A notice, order, or document, by this order required or authorized to be served on the owner or occupier of premises may be served by delivering the same, or a true copy thereof, to some person on the premises, or if there is no person on the premises to whom the same can with reasonable diligence be delivered, by fixing the notice on some conspicuous part of the premises.

Revocation of Order.

Revocation of order where undertakers are insolvent.

E. L. Act, 1882, sec. 6 (*f.*)

67. If at any time after the commencement of this order the local authority make a representation to the Board of Trade that the undertakers are insolvent, and that in consequence of such insolvency they are unable to execute works or to supply electricity in accordance with the terms of this order, the Board of Trade shall inquire into the truth of such representation, and if upon inquiry they are satisfied of the truth of the representation, they shall, upon the application of the local authority, revoke this order as to the whole or any part of the area of supply; and thereupon all the powers of the undertakers for the supply of electricity within the area of supply, or such part thereof as aforesaid, shall absolutely cease and determine.

Provisions where order revoked.

68. If the Board of Trade at any time revoke this order as to the whole or any part of the area of supply, the following provisions shall have effect:—

Clauses 8, 9 and 10.

(*a.*) Any money which may have been deposited or secured by the undertakers under the provisions of this order in respect of such area or part thereof (as the case may be) and which may not have been repaid or released to the undertakers, shall be applied rateably in satisfying the claims of the local authority and any other persons to compensation for any damage sustained by them by reason or in consequence of the execution of any works within such area or part thereof as aforesaid, or for any expenses to which such local authority or persons may have been put in removing any works of the undertakers within such area or part thereof under the provisions of this order: and in every such case the amount of compensation to be paid in respect of the various claims, and the persons to whom it is to be paid shall be determined by an arbitrator to be appointed by the Board of Trade, whose decision shall be final and binding on all persons.

(*b.*) Within one month after the date of the revocation, the local authority, if they think fit, may by notice in writing require the undertakers to sell, and thereupon the undertakers shall sell to them their undertaking upon terms of paying the then value of all lands, buildings, works, materials, and plant of the undertakers suitable to and used by them for the purposes of the undertaking, such value being estimated in manner directed by the principal Act in the case of purchases effected by the local authority under section twenty-seven of that Act.

(c.) Where no such notice is given to the undertakers by the local authority, as in the last sub-section mentioned, the local authority, and any persons who may be liable to repair any street or part of a street in which any works of the undertakers may have been placed, may forthwith remove such works, with all reasonable care, and the undertakers shall pay to the local authority or such other persons as aforesaid such reasonable costs of such removal as may be specified in a notice to be served on the undertakers by such local authority or other persons, or, if so required by the undertakers, within one week after the service of such notice upon them, as may be settled by arbitration.

If the undertakers fail to pay such reasonable costs as aforesaid within one month after the service upon them of such notice, or the delivery of the award of the arbitrator, as the case may be, the local authority or other such persons as aforesaid may without any previous notice to the undertakers (but without prejudice to any other remedy which they may have for the recovery of the amount), sell and dispose of any such works as aforesaid either by public auction or private sale, and for such sum or sums and to such person or persons as they may think fit; and may, out of the proceeds of such sale, pay and reimburse themselves the amount of the costs so specified or settled as aforesaid, and of the costs of sale, and the balance (if any) of the proceeds of the sale shall be paid over by them to the undertakers.

General.

Nature and amount of security.

69. Where any consumer is required under this order to give security to the undertakers, such security may be by way of deposit or otherwise, and of such amount as he and the undertakers agree on, or as, in default of agreement, may be determined on the application of either party by two justices, who may also order by which of the parties the costs of the proceedings before them shall be paid, and the decision of the justices shall be final and binding on all parties: Provided that

Provisional Order. Chelsea.

where any such security is given by way of deposit the undertakers shall pay interest at the rate of five pounds per centum per annum on every sum of ten shillings so deposited for every six months during which the same remains in their hands.

Proceedings where approval of Board of Trade is required.

70. Where under the provisions of this order the approval of the Board of Trade is required to be given in any case such approval shall be signified in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade, and all costs and expenses of or incident to any application for such approval, including the costs of the tests (if any) which may be required to be made by the Board of Trade for the purpose of determining whether such approval should be given, shall be borne and paid by the applicant or applicants for such approval; provided always that where any approval is given by the Board of Trade to any plan, pattern, or specification, they may require such copies of the same as they may think fit to be prepared and deposited at their office at the expense of the said applicant or applicants, and may from time to time if they think fit revoke any approval so given, or permit such approval to be continued subject to such modifications as they may think necessary.

Notice of approval of Board of Trade, &c. to be given by advertisement.

71. Where the Board of Trade, upon the application of the undertakers, give any approval or grant any extension of any time limited for the performance of any duties by the undertakers under this order, or where the Board of Trade, upon the application of the local authority, revoke this order as to the whole or any part of the area of supply, notice that such approval has been given, or such extension of time granted, or such revocation made, shall be published by public advertisement once at least in each of two successive weeks in some one and the same local newspaper by the body by whom such application was made as aforesaid.

Notice of applications for extension of time to be given to local authority.

72. Where any application is made to the Board of Trade to extend any time limited for the performance of any duties by the undertakers under this order, notice of such application shall be served on the local authority by the undertakers, and an opportunity shall be given to the local authority to make representations or objections with reference thereto.

Recovery of penalties. E. L. Act, sec. 6.

73. All penalties under this order, the recovery of which is not otherwise specially provided for, may be recovered in a summary manner before a court of summary jurisdiction.

By the Summary Jurisdiction Act 1879 (42 and 43 Vict. c. 49, secs. 6, 35) it is provided that sums recovered on complaint and not on information, are to be civil debts, enforced by distress, but not giving rise to imprisonment for non-payment except where the debtor is proved to have had means to pay.

On the other hand penalties are to be recovered by information, and the defaulting party may be imprisoned if he does not pay them.

Undertakers to be responsible for a damages.

74. The undertakers shall be answerable for all accidents, damages, and injuries happening through the act or default of the undertakers, or of any person in their employment, by reason or in consequence of any of the undertakers' works, and shall save harmless all bodies having the control of streets or public roads, collectively and individually, and their officers and servants, from all damages and costs in respect of such accident and injuries.

As to mortgages.

75. Nothing in this order shall prevent the undertakers borrowing money on the security of mortgages of the undertaking, or shall make the consent or approval of the Board of Trade necessary to the validity or effect of any such mortgage: Provided that every mortgage of the undertaking shall be deemed to comprise all purchase money which may be paid to the undertakers in the event of any compulsory sale of the undertaking or any part thereof to the local authority, under section twenty-seven of the principal Act, or under this order, and that any mortgage granted by the undertakers shall not be a charge upon the undertaking or any part thereof in the event of the undertaking or such part being purchased by the local authority as aforesaid, and that every mortgage deed granted by the undertakers shall be endorsed with notice to that effect.

Saving rights of the Crown in the foreshore.

76. Nothing in this order shall authorise the undertakers to take, use, or in any manner interfere with any portion of the shore or bed of the sea, or of any river, channel, creek, bay, or estuary, or any right in respect thereof, belonging to the Queen's most Excellent Majesty, in right of Her crown, and under the management of the Board of Trade, without the previous consent in writing of the Board of Trade on behalf of Her Majesty (which consent the Board of Trade may give); neither shall anything in this order contained extend to take away, prejudice, diminish, or alter any of the estates, rights, privileges, powers, or authorities vested in or enjoyed or exerciseable by the Queen's Majesty, Her heirs or successors.

Works not to be constructed on shore of navigable waters without consent of Board of Trade.

77. The undertakers shall not construct on the shore of the sea, or of any creek, bay, arm of the sea, or navigable river communicating therewith, where and so far up the same as the tide flows and re-flows, any work without the previous consent of the Board

Provisional Order. Chelsea.

of Trade, to be signified in writing under the hand of one of the Secretaries or Assistant Secretaries of the Board of Trade, and then only according to such plan and under such restrictions and regulations as the Board of Trade may approve of, such approval being signified as last aforesaid; and where any such work may have been constructed, the undertakers shall not at any time alter or extend the same without obtaining previously to making any such alteration or extension the like consents or approvals. If any such work be commenced or completed contrary to the provisions of this order, the Board of Trade may abate and remove the same, and restore the site thereof to its former condition at the cost and charge of the undertakers; and the amount of such cost and charge may be recovered by the Board of Trade summarily as a civil debt.

The word "navigable" is here used in the same sense as in fishery cases, and means within the ebb and flow of the tide.

The soil of such rivers is in the Crown and the public have a right of way over them and to fish in them.

The shore of the sea up to ordinary high-water water mark is also in the Crown.

Undertakers not exempted from indictment.

78. Nothing in this order shall exonerate the undertakers from any indictment, action, or other proceeding for nuisance in the event of any nuisance being caused by them.

The liability to an action for a nuisance always existed at common law, and this sentence makes the above penalties merely cumulative.

Provision as to general Acts. E. L. Act, secs. 2, 34

79. Nothing in this order shall exempt the undertakers or their undertaking from the provisions of any general Act relating to the supply of electricity which may be passed in this or any future session of Parliament.

SCHEDULES.

SCHEDULE A.

(See clauses 5, 9.)

Schedules. Chelsea.

So much of the parish of Chelsea as lies north of the line of Pont Street and Grove Place, the houses on both sides of Pont Street and Grove Place being included within the area.

The streets within the aforesaid area along which the undertakers are to lay distributing mains within two years from the commencement of this order are such portions of the following streets and parts of streets as lie within the aforesaid area—

Pont Street.
Hans Place.
Sloane Street.
Cadogan Place.
Harriet Street.
Lowndes Square.
Lowndes Street.

SCHEDULE B.

(See clauses 7, 22.)

So much of the parish of Chelsea as lies north and east of the line formed by College Street, Markham Street, King's Road, from the corner of Markham Street to the corner of Smith Street, and Smith Street, not including the area described in Schedule A.

SCHEDULE C.

(See clauses 49, 50.)

The term "unit" as used in this schedule shall be deemed to mean the energy contained in a current of 1,000 ampères flowing under an electro-motive force of one volt during one hour.

Schedules.
Chelsea.

SECTION 1.

Where the undertakers charge any consumer by the quantity of energy contained in the supply given to him, they shall be entitled to charge him at the following rates per quarter:—For any quantity up to 100 units, three pounds ten shillings; for each unit over 100 units, seven pence per unit.

SECTION 2.

Where the undertakers charge any consumer by the actual quantity of electricity supplied to him, they shall be entitled to charge him according to the rates set forth in section 1 of this schedule, the quantity of energy contained in the supply given to him being taken to be the product of the actual quantity of electricity supplied to him and the standard pressure at the point of junction of the mains and the service lines by which he is supplied.

SECTION 3.

Where the undertakers charge any consumer by the number of hours during which he actually uses his supply, they shall be entitled to charge him at the rates specified in section 2 of this schedule, the quantity of electricity supplied to him being calculated on the supposition that the consumer uses the maximum current specified by him under the provisions of this order during all the hours that he has used the supply.

SCHEDULE D.

(See clause 14.)

List of private streets, railways, and tramways, which may be broken up by the undertakers in pursuance of the special powers granted by this order.

Provisional Orders obtained by Local Authorities.

Where the Provisional Order is obtained by the Local Authority, it will be somewhat different in form from the preceding, in that the duties of the undertakers to the local authority are omitted.

The clauses relating to capital (8, 9, 10) are omitted, as also 14 e. & f., 17, 25 & 29; 67 & 68 are much modified, and a clause is inserted as follows with regard to the Application of Revenue:—

All moneys from time to time received by the undertakers in respect of the undertaking, except borrowed money, shall be applied by them as follows:

Application of moneys.

(1.) In payment of the working and establishment expenses and cost of maintenance of the undertaking, including all costs, expenses, and damages incurred or payable by the undertakers, consequent upon any proceedings by or against the undertakers, their officers or servants, in relation to the undertaking.

(2.) In payment of the interest on any mortgages, stock, or other securities, granted and issued by the undertakers in respect of money borrowed for electricity purposes.

(3.) In providing any instalments or sinking fund required to be provided in respect of moneys borrowed for electricity purposes.

(4.) In payment of all other their expenses of executing this order.

(5.) In providing a reserve fund, if they think fit, by setting aside such money as they may from time to time think reasonable, and investing the same and the resulting income thereof in Government securities, or in any stock or securities of the undertakers, and accumulating the same at

Provisional Order. Chelsea.

compound interest until the fund so formed amounts to one-tenth of the aggregate capital expenditure on the undertaking, which fund shall be applicable from time to time to answer any deficiency at any time happening in the income of the undertakers from the undertaking, or to meet any extraordinary claim or demand at any time arising against the undertakers in respect of the undertaking, and so that if that fund is at any time reduced, it may thereafter be again restored to the prescribed limit, and so from time to time, as often as such reduction happens.

And shall carry the net surplus remaining in any year, and the annual proceeds of the reserve fund, when amounting to the prescribed limit, to the credit of the local rate as defined by the Electric Lighting Act, 1882, or at the option of the undertakers, shall apply such surplus, or some part thereof, to the improvement of the borough and public benefit of the inhabitants, or in reduction of the capital moneys borrowed for electricity purposes.

Provided always, that if the surplus shall in any year exceed seven pounds per centum per annum upon the aggregate capital expenditure on the undertaking, the undertakers shall make such a rateable reduction in the charge for the supply of electricity as in their judgment will reduce the surplus to the said maximum rate of profit.

Any deficiency of income in any year shall be charged upon and payable out of the local rate.

FORMS

UNDER THE ELECTRIC LIGHTING ACT, 1882.

FOR PROVISIONAL ORDERS.

(N.B.—All forms are usually on foolscap paper 8 *in. by* 13 *in. and on one side only of the paper. These given below are for Provisional Orders, but can be easily modified to suit application for licenses.)*

FORM 1.

(*Specimen form of notice to Local Authority of intention to apply for a Provisional Order within the district. To be given before July* 1*st in writing, and served as provided in Rule VIII. See Electric Lighting Act, sec.* 4, *subsec.* 1.)

Notice of application for P. O.
Page 6.

Board of Trade
Session .

Electric Lighting Act, 1882.
[. . . . *name of proposed area* . . . .]

SIR,

We the [*name of applicants* . . . .] beg to inform you that application is intended to be made on or before the 21st day of December next by memorial to the Board of Trade in pursuance of the Electric Lighting Act, 1882, for a Provisional Order, to be confirmed in Parliament in the ensuing Session, whereby it is proposed to authorize use the said [*name of applicants* . . . .] to supply electricity for any [public or private] purposes within the area of the jurisdiction of the [*name of the local authority* . . . .]

We are,
Sir,
Your obedient servants.
. . . .
[*If a company, the secretary may sign it.*]

To [*name of local authority.*]

FORM. 2.

Specimen of a form of notice convening a meeting to approve of the application by a local authority for an Electric Lighting Provisional Order. The following notice is for a borough, others for urban or rural districts would be very similar. The notices are prescribed by the Electric Lighting Act, sec. 3, *subsec.* 6 *and sec.* 4, *and Rule VII., and are directed to be given in "the usual manner."*

Specimen notice convening meeting of local authority to apply for P. O.
Page 6.

Borough of . . . . .

In pursuance of the Act passed in the sixth year of the reign of His late Majesty King William IV. intituled an Act to provide for the regulation of Municipal Cor-

Provisional Order Forms.

porations in England and Wales, I do hereby give notice that a special meeting of the Council of the said Borough will be held at . . . . . on the . . . day of . . . . . 18 . at . . . o'clock in the . . . noon; and at which meeting the Council will act as the sanitary authority for the said Borough, and determine whether the said authority shall apply to the Board of Trade for a Provisional Order to supply electricity for [public and private] purposes within the area of [. *the proposed area* . . .] and for what period.

Given under my hand this . . day of . . . 18 . .

. . . . Mayor.

FORM 3.

Form of resolution.

Specimen form of a resolution passed at the meeting convened as above in a Borough.

At a meeting of the Council of the Borough of . . . . . acting as the urban sanitary authority for the said Borough held on the . . day of . . . 18 .

RESOLVED: that application be made to the Board of Trade for a Provisional Order under the Electric Lighting Act, 1882, for a period of . . . . . . and that the Electric Lighting Committee be empowered to do everything necessary in the matter.

FORM 4.

Form of advertisement. Page 7.

Specimen form of a notice by advertisement inserted in the " Gazette" and local newspapers, of an intention to apply for a Provisional Order. See Electric Lighting Act, 1882, *sec.* 3, *subsec.* 5, *and Rule IX. Extracted from the official "Gazette," November* 21, 1882, *page* 5252.

Board of Trade—Session 1883.
"Electric Lighting Act, 1882."
Richmond Electric Lighting.

(Power to the South Eastern (Brush) Electric Light and Power Company Limited, to produce, supply, and store Electricity for Lighting and other Purposes, and for those Purposes to break up public and private Streets and other Places in the Parish of Richmond, in the County of Surrey; and to erect, lay down, provide, and maintain Wires and other Apparatus and Works; Acquire Land and other Rights, and supply Lamps, Meters, and Fittings; Powers to the Local Authority and others, and Agreements with them; Power to demand and recover Rents and Charges, &c., and to make Regulations as to Fittings, &c.; Incorporation of Acts.)

NOTICE is hereby given, that application is intended to be made by the South Eastern (Brush) Electric Light and Power Company Limited, of No. 110, Cannon-street, in the city of London (hereinafter called "the Company") to the Board of trade, on or before the 21st day of December next, under the provisions of the "Electric Lighting Act, 1882," for a Provisional Order for the following purposes:—

To authorise and empower the Company to supply and store electricity as defined by the said Act, for all or some of the public and private purposes as defined by the said Act within the area hereinafter mentioned, and for those purposes to enter upon, break up, and interfere with all streets, roads, and public places, ways, footpaths, railways, tramways, canals, towing paths, bridges, culvers, sewers, gas and water mains and pipes, and telegraph and pneumatic tubes and pipes in the said area, and to lay down, set up, maintain, renew, or remove either above or under ground or otherwise, pipes, tubes, wires, posts, apparatus, or other works or things required for enabling the Company to supply, produce, store, convey, transmit, or distribute electricity for the several private and public purposes aforesaid, within the said area, and all other works to carry into effect the objects of the proposed undertaking.

To enable the Company to purchase, hold, acquire, or take on lease any lands or interests, or easements in land, and to erect, maintain, use, and work upon such land all necessary stations, together with all storehouses, engines, machinery, apparatus, works, and appliances, for the production, storage, and distribution of electricity.

To authorise the Company to manufacture, hire, sell, and let all necessary machines, lamps, accumulators, fittings, plant, machinery, and other matters or things of whatever description, required for the purposes aforesaid.

To authorise the Company to enter upon any houses, buildings, lands, and premises supplied by them for any purpose relative to such supply.

To enable the Company on the one hand, and the local authority on the other hand, to enter into agreements as to the supply of electricity, and as to the breaking up and interfering with any streets, roads, ways, public footpaths, and public places as aforesaid, and if necessary to authorise such local authority to exercise the powers with respect to the breaking up of streets and other places, and all or any of the other powers proposed by the intended Order to be conferred upon the Company.

To incorporate with the Provisional Order and extend and apply to the proposed undertaking and works, and to the Company as undertakers of the same, all or some of the provisions of the "Electric Lighting Act, 1882," and of the Acts or portions of Acts incorporated therewith, and to confer upon the Company all or some of the powers within the area of supply hereinafter mentioned, that by the "Electric Lighting Act, 1882," are conferred upon undertakers as defined by such Act, and so far as may be necessary for the purposes of the Provisional Order, or as may be deemed expedient to alter, amend, repeal, or extend all or some of the provisions of those Acts, and to confirm or give effect to any agreement with any local authority or other Corporation or person relative to the said Order or the undertaking proposed to be authorised thereby, and to make all such other regulations and conditions as the said Act authorises or requires, or the Board of Trade may prescribe with respect to all or any matters in connection with the proposed undertaking.

To authorise the Company to take, collect, and recover rates, rents, and charges, and to prescribe the same, and to enable the same to be from time to time revised.

The area of supply within which it is proposed that the provisions of the said Order shall be in force and have effect is the parish of Richmond, in the county of Surrey.

The streets and other places in, over, or along which it is proposed to place any electric lines or other works, are all the streets and other places within the said area of supply, and among such streets and places, it is more particularly proposed to place electric lines and works in, over, or along the following streets and places (but not to the exclusion of the other streets and places within the said area) that is to say:—

Kew-road, from the London and South Western Railway Station to George-street.

George-street.

Hill-street, from George-street to the junction of Upper Hill-street and Lower-road.

The railways and tramways which the Company propose to take power to break up are as follows;

The London and South Western Railway.

The canals and navigable rivers which the Company will be empowered to cross are as follows :—

River Thames.

The draft of the proposed Provisional Order will be deposited at the Office of the Board of Trade on or before the 21st day of December next, and printed copies of the Draft Provisional Order when applied for, and of the Provisional Order when made, will be furnished at the price of one shilling for each copy to all persons applying for the same at the office of the undersigned Walter Webb and Co., 23, Queen Victoria-street, in the city of London, and at the Selwyn-court Estate Office, Ennerdale-road, Kew-gardens, Richmond, in the county of Surrey.

Every local or other public authority, company, or person desirous of making any representation to the Board of Trade, or of bringing before them any objection respecting the application, may do so by letter addressed to the Board of Trade marked on the outside of the cover enclosing it, "Electric Lighting Act," within two months from the date hereof.

Dated this 18th day of November, 1882.

Walter Webb and *Co.*, 23, Queen Victoria-street, London, E.C., Solicitors and Parliamentary Agents.

Page 7.

FORM 5.

Specimen form of memorial praying for a Provisional Order. See Rules III. V. VI.

(. . . . . . . *Description of the proposed undertaking; this must correspond with that in the advertisement in the last Form 4, see Rule III.*)

To the Board of Trade.

The Memorial of the . . . . . .
. . . .
the promoters of the . . . . . .
. . . . . District (or area) Electric
Lighting Provisional Order.

SHOWETH,

1. Your memorialists have published in accordance with the requirements of the Electric Lighting Act, 1882, the following advertisement. [Here set out a copy of the advertisement, or if in print, let it be interleaved.]

2. Your memorialists request the consent of the Board of Trade to enable them to break up the streets not repairable by the local authority which are specified in the list deposited with this memorial (*as to the necessity of this see Rule VI., clause* 7).

Page 77, and Provisional Order, clause 14.

3. Your memorialists have also deposited in accordance with the requirements of the said Act copies of the said advertisement, and of a published map of the district showing the boundaries of the proposed area of supply and the streets and places in over or along which it is proposed to place any electric lines or other works.

Your memorialists therefore pray that a Provisional Order may be made in the terms of the draft proposed by your memorialists or in such other terms as may seem meet.

○ Seal of applicant.

(Signed.)

Provisional Order Forms.
Page 7.

FORM 6.

(*This form together with forms* 7, 8, 9, *must be deposited with the memorial, Form* 5, *on or before December* 21*st, Rules III., V., VI.*

Board of Trade.
Session 18 .

The Electric Lighting Act, 1882.
. . . . . . District
Electric Lighting.

List of local authorities in whose area the area of supply will be situate.

. . . .
. . . .

FORM 7.

Page 8.

(*Form for list of streets, railways, and tramways not repairable by the local authority, which the applicants propose to take powers to break up. See Rule VI. and Electric Lighting Act, sec.* 13.)

(*Heading same as Form* 6. *The lists should separate the streets from the railways, and from the tramways.*)

The following are the streets not repairable by a local authority, and the railways and tramways which the applicants propose to take powers to break up.

. . . .

FORM 8.

(*The list of canals is in form similar to the last, with a similar heading, Rule VI.*)

The following is a list of the canals and navigable rivers which the applicants desire to be empowered to cross.

. . . .

FORM 9.

Page 8.

(*The heading may be the same as Form* 6. *The nature of the capital should then be stated, and how it is to be raised. The two following forms will serve as specimens, Rule VI.*)

The applicant company proposes to employ, and so far as may be necessary to expend a sum of £ , in connexion with the undertaking and also such further sum or sums as shall afterwards be found to be required for the purpose of properly carrying the order into effect.

It is proposed to provide such capital out of the funds of the applicant company.

(*In the case of a local authority to whom the Local Loans Act*, 1875, *applies.*)

It is proposed to employ such capital as may be necessary from time to time to carry out the works mentioned in the proposed Provisional Orders. To be raised by debentures under the Local Loans Act, 1875, charged on the local rate or property specified at the time of the issue thereof.

FORM 10.

Page 9.

(*Form of certificate of the clerk of the local authority, that a resolution has been duly passed by the local authority that a Provisional Order shall be applied for, and that notice of the meeeting was duly given, &c. This is to be furnished to the Board of Trade with the proofs before February 25th, on the day fixed by the Board of Trade for that purpose. Electric Lighting Act, sec.* 3, *subsec.* 6, *Rule VII.*)

Provisional Order Forms.

Board of Trade
Session 18 . .

Electric Lighting Act, 1882.
. . . . Electric Lighting
Provisional Order.

Certificate.

To the Board of Trade.

I the undersigned, being Clerk to the [urban sanitary authority] of the [Borough of] who are the local authority within the meaning of the Electric Lighting Act, 1882, for the district comprising the area within which it is proposed to supply electricity under the said Act, and by virtue of such Provisional Order as is mentioned in the resolution hereinunder set forth do hereby certify that at a special meeting of the said local authority duly convened and held after one month's previous notice of the same and of the purposes thereof (a copy of which notice is set forth in Schedule I.) had been given in the manner in which notices of meetings of such local authority are usually given, the resolution (of which a copy is set forth in Schedule II.) was duly passed by such local authority.

SCHEDULE I.

(*Copy of the notice, see e.g. Form* 2.)

SCHEDULE II.

(*Copy of the resolution, see e. g. Form* 3.)

Given under my hand this day
of . . . , 18 . ,
. . . . . . , Clerk to the above-named
Local Authority.

FORM 11.

Page 7. (*Form of the notice which by Rule IV. is to be inserted at the end of the draft license or order, and which is also to be inserted in the advertisements, Rule IX.*)

NOTICE.

Every local or other authority, company, or person desirous of making any representation to the Board of Trade, or of bringing before them any objection respecting this application, may do so by letter addressed to the Board of Trade, marked on the outside of the cover enclosing it "Electric Lighting Act," within two months from the date of the newspaper containing the first advertisement of such application [and a copy of such objections should at the same time be sent to (. . . . . the applicant's solicitors or agents—). *But this is not required by the Act or Rules, and objectors will probably use their own discretion with regard to it.*]

The above Forms may easily be modified to suit applications for licenses, as pointed out in the introduction, page 12.

PART II.

NOTES ON ELECTRICITY.

CHAPTER I.

ELEMENTARY PRINCIPLES.

BEFORE proceeding to explain the construction of various apparatus used in electric lighting, I propose to state shortly the scientific principles upon which these instruments depend.

SEC. 1.—*Magnetism.*

Iron and steel when magnetised acquire very remarkable properties. When a piece of iron or steel is made into a magnet, it attracts pieces of non-magnetised iron placed near it. This is familiar to children, who have long used as a toy a magnet to attract fish or swans floating in a basin of water. But when two magnets are brought near to one another, this phenomenon of attraction is found to be varied. For opposite ends of the same magnet are found to have different qualities. Thus if one end of a magnet attract one end of another magnet, then the same end of the first magnet will repel the reverse end of the other and *vice versâ.*

It appears as though magnetism were of two kinds or natures. And it is found, that it is impossible to obtain a magnet with magnetism of one kind at one end, without having a magnetism of an equal amount but contrary nature at the other end. This phenomenon is called polarity; and if a bar magnet were cut in two at the middle, each separate piece would exhibit the properties of a complete magnet. Nay more, if the subdivision were indefinitely continued, each piece would still exhibit polarity: so that you cannot cut one pole away from another. Magnetism is thus a sort of relativity of attraction rather than an absolute property of any definite particle. And again, if two magnets are put together, so that their opposite (or mutually attracting) poles touch, they will, so long as they are together, form the exact equivalent of a single magnet. And in like manner any number of magnets may be joined into one, the joined poles of each disappearing or coalescing so to speak into the two poles of the united system.

But as has been said, the poles of a magnet not only attract and repel the poles of other magnets, but also attract iron and steel which are not magnetic. This occurs by reason of what is termed induction. When a piece of iron or steel is brought near the pole of a magnet, it immediately itself becomes a magnet with poles opposite to those of the inducing magnet. Thus the magnet A B (fig. 1) will convert the pieces of iron round it into magnets with the polarity indicated by the shaded lines. And having once induced magnetism in these pieces of iron, the magnet A B will then attract them just as it would attract other magnets. We now come to a curious difference of property between iron and steel. Steel is probably an alloy of iron with carbon. At all events whatever its nature it has a property quite different from that of iron in this, that it retains magnetism. A piece of soft iron when magnetised loses its magnetism almost the instant the magnetising influence is removed. But a piece of steel remains magnetic, and up to a certain point called the point of saturation, and which depends on its shape and quality, can be made a permanent magnet. Thus if C D, one of the pieces of iron in fig. 1, be turned round so that C were presented to the pole A, the magnetism of C D would be immediately reversed, and the end C would be therefore attracted as before. But if C D were a

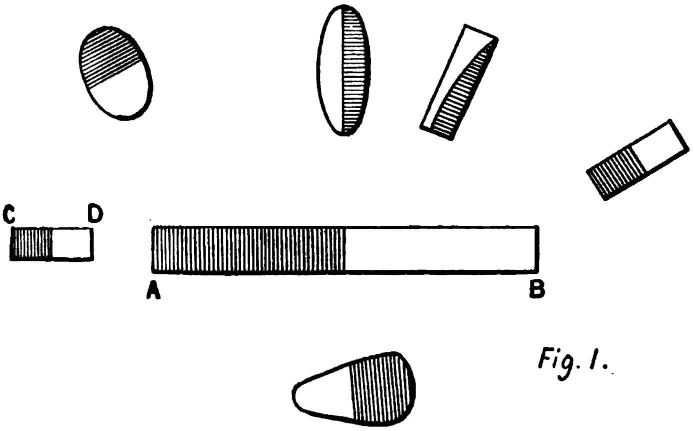


Fig. 1.

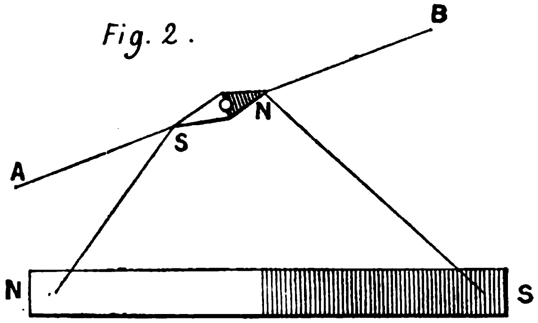
piece of steel, then (unless it were brought so near A B that its residual magnetism were overpowered by fresh induction in its new position), its end C would be *repelled*, and D would be attracted. And this is the great difference between iron and steel. Other metals such as nickel possess magnetic qualities, but none can at all compare with iron.

For some reason which is imperfectly understood, the earth acts as an enormous magnet, whose poles are not far from the poles of the axis of rotation. Hence a magnetic needle, if balanced, will have one of its poles attracted towards one pole of the earth, and one repelled. It is usual to call the end which is attracted the north pole of the needle; and generally, that pole of a magnet which is attracted by that magnetic pole of the earth which is situate in North America, is called the north pole. According to this, the pole of the earth which is in North America is truly a south pole. To avoid confusion, Mr. Sylvanus Thompson proposes the use of the word north-seeking pole, but I have used the old terms.

The permanent magnetisation of steel is much assisted by several mechanical and chemical treatments. Thus if an unmagnetised steel bar is placed pointing towards the north, it will not retain any appreciable charge of magnetism; but if in that position it is struck with a hammer several times, the molecular changes in it are facilitated, and it becomes a permanent magnet of appreciable though feeble strength.

The position that a magnetic needle placed near a magnet will take up, depends on the fact that each of its ends is attracted and repelled by the poles of the magnet. Thus (Fig. 2) a magnetic needle N.S. pivoted upon a point, which is placed near a magnet N.S., but nearer to N. than to S., will have its S. pole strongly attracted to N., to which it is nearest, and its N. pole less strongly attracted to S., from which it is farthest. Under the influence of

Fig. 2.



these opposing influences it will take up an intermediate position, and lie somewhere in a line A B, pointing neither to N. nor to S., but halting as it were midway between them.

It has been experimentally found that the attractive force of the pole of a magnet upon a magnetic particle placed at any distance from it varies inversely as the square of that distance; that is, becomes smaller or greater at different distances in proportion to the squares of those distances. Thus, if the pole is one inch distance, and the attractive force at that distance were equivalent to a one ounce weight, then at two inches distance the attractive force would be equivalent to a quarter ounce weight.

This law of the inverse square is very common in nature. The earth's attractive force of gravitation obeys it; so also does the attractive force of electricity. And in fact wherever any influence or energy is radiated from a centre in all directions, the intensity of that energy at different distances from its source, varies inversely as the squares of those distances. It is as though a certain amount of energy going in one direction became more and more spread out as it proceeded, getting weaker in the process. Thus, for example, a candle (Fig. 3), placed at A, would shed the same quantity of light over the areas B, C, or D. But these areas are proportional in size to the *squares* of their distances from A. Thus, the intensity of light on any part of B is stronger than the intensity of light at any point of C, in the proportion of the square of A C to the square of A B. In fact, as the energy is dispersed, its intensity diminishes as the area over

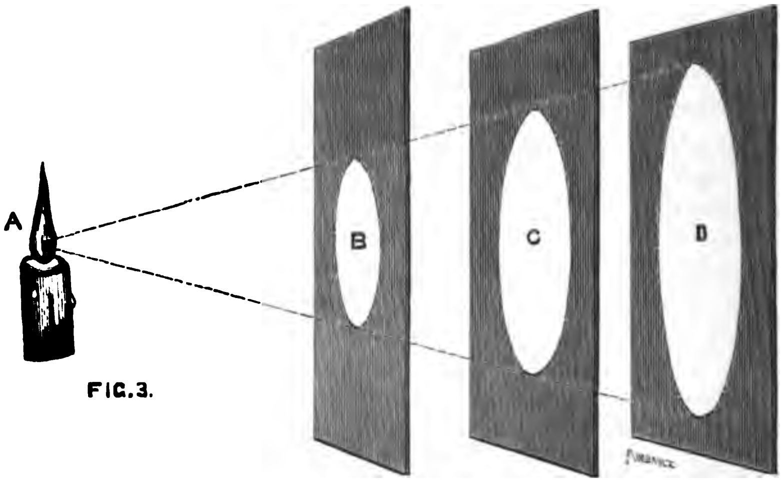


FIG. 3.

which it is spread increases. This is the principle upon which an efficient but simple photometer is made for calculating the number of candle-power possessed by electric lamps. This law of the inverse square seems true of all radiant energies, and is no less true of sound and heat and of light, than of gravitation, electric attraction, and magnetic attraction.

Returning, then, to our magnetic needle, we find that if the point upon which it is pivoted is fixed near a magnet, the direction which the needle will assume is dependent upon the directions of the lines drawn from the pivot towards the poles of the magnet. If the pivot is equidistant from the two poles of the magnet, the direction of the needle will be parallel to that of the magnet. If the pivot is nearer the north pole of the magnet, then the direction of the needle will be inclined to the magnet, pointing, not *towards* the north pole, but *rather more towards* it than towards the south. And *vice versâ*. Fig. 4 represents a large number of magnetic needles mounted on fixed pivots. The directions which these needles will assume may be determined either experimentally or by mathematical calculations based on

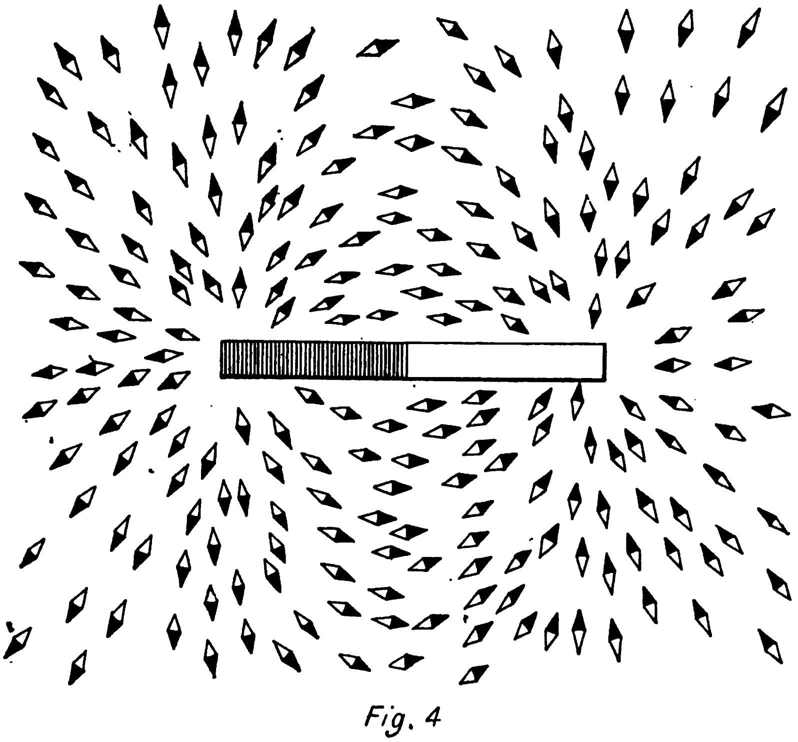


Fig. 4

the principle of the inverse square above stated. These two methods coincide in their results, and show that the needles take up their positions according to a definite law, or mode of arrangement. This has given rise to a very important physical conception. An inspection of Fig. 4 will show that the directions of the needle seem to follow curved lines proceeding from pole to pole. This has suggested the assumptions; (1) that from every north pole lines of force proceed in infinite numbers; (2) that these lines are repelled from the pole from which they proceed, and being also mutually repellent, tend to radiate in all directions; (3) that these lines are attracted by every south pole, and therefore always tend to proceed towards it. With a single north pole, the lines of force would radiate from it like rays of light in straight lines in all directions. But as every magnet must have a south pole, which, on the above assumption, will attract the lines of force proceeding from the north pole, they are bent round like a series of curves, re-entering the magnet from all directions at the south pole.

It has been said that these lines of force are mutually repellent. Hence they do not rush directly from one pole to another in straight lines, but are, so to speak, jostled or pushed out of their paths, only a few getting along in a straight line, the rest being pushed out and forced to take a more circuitous route. When they arrive at the south pole, they are supposed to enter the substance of the magnet, to go along it from south to north, and then emerge again at the north pole, and so go round and round. The lines of force as thus conceived form what is called a magnetic field entirely surrounding the magnet. The comparative intensity of the magnetism in different parts of the magnetic field is conveniently indicated by the relative number of lines of force, being fewer and more sparse in the weaker or more distant parts of the field, more numerous and dense in the stronger or nearer parts of it.

This is a very artificial assumption. The lines of force are merely fictions of the imagination, and have no more real existence than the parallels of latitude on the earth. Still they will be found to be exceedingly useful when we come to treat of the action of dynamos. This mode of regarding the action of magnets was a very favourite one with Faraday. The tendencies of the lines of force may be very elegantly shown by covering a magnet with a piece of paper sprinkled with iron filings. When the paper is gently tapped, the particles of iron rush into the shapes shown in Fig. 5; forming groups of curved lines which show accurately the directions of the curves of force, and in a somewhat approximate manner the intensity of the field at different parts. There is one other property of iron which must be mentioned before we leave the subject of magnetism. If a piece of iron is placed in the field of a magnet, as in Fig. 6, it attracts to itself the lines of force near it, many of which enter it, and go through it. Other metals, such as copper, would repel these lines of force, though very feebly. Steel attracts the lines of force less than soft iron, which is the best substance known for this purpose. This property of iron is largely used in the construction of dynamos, as will presently be seen.

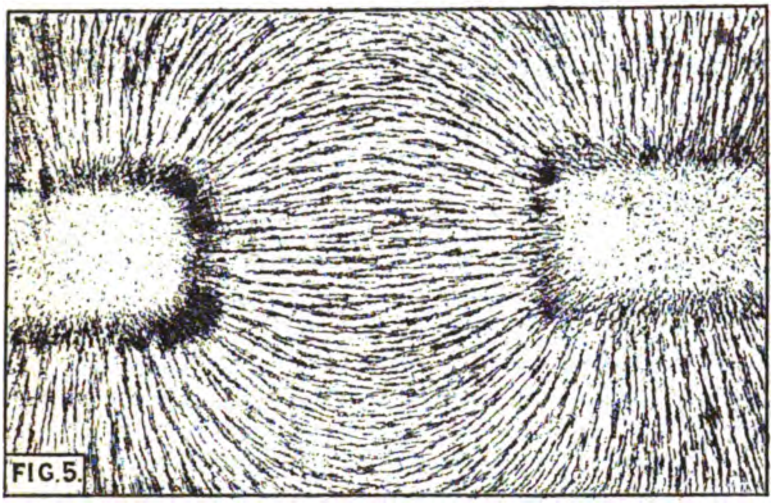


FIG. 5.

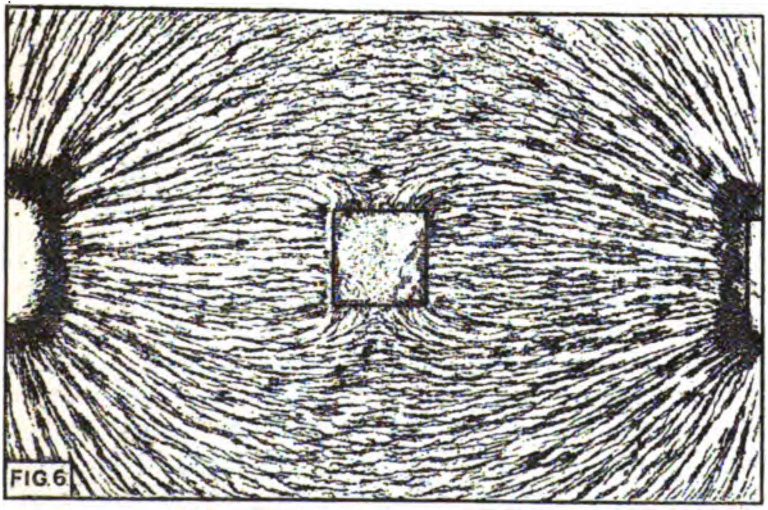


FIG. 6

SEC. 2.—*Electricity.*

No one knows what electricity is, nor is it material to our present purpose to inquire. It is known by its effects. These effects show, that whatever it is, it has very curious properties. It seems to be closely connected with light, and to depend in some manner on the ether, that is the imponderable fluid which is supposed to penetrate all space, and the waves or vibrations of which constitute light and heat. Electricity can exist either in motion or at rest. This condition is called static, or stationary, while when the electricity is moving, it is said to be in a dynamic condition, and this latter is the only state in which it can be used by means of dynamo machines for electric lighting.

If we rub a piece of glass or resin with silk or fur, we find that these bodies become electrical. The electrified matter exhibits polarity. Instead of being designated by the names north and south, these opposite states are called positive and negative electricity. But there is this difference between the properties of an electrified body and a magnet; that whereas a magnet if cut in two, becomes two complete magnets, a body with positive electricity at one end and negative at the other, may be divided so as to leave one half permanently positive and the other permanently negative. And when two different surfaces are rubbed together, one becomes positively electrified and the other negatively. Still, however, whenever you have positive electricity, you always must have somewhere in the universe an exactly equivalent negative. They may be separated by leagues, but still the existence of the one always seems in some mysterious way to be dependent on that of the other. Moreover, if they once get together all action disappears, and indeed the electricity itself seems to vanish out of existence. In fact, electricity may by friction be apparently produced out of nothing, in equal corresponding quantities of opposite nature. These, however, must be kept apart, for if they can, they will instantly unite (doing violent work in their struggles to get together); but when united they seem to vanish into the nothing from whence they came. The expenditure of energy is requisite to call them into existence in their separate states, and to separate them one from another. This separation they resist (with a force varying as the inverse square of the distance), and when they can, they will rush together in order to coalesce into their previous nothingness, and perhaps light a city on their way. But though a quantity of positive electricity attracts a corresponding quantity of negative, it does not exhibit any special partiality to any particular negative electricity, as for example, to that from which it was originally separated. It seeks negative electricity wherever it can find it.

Electricity is imponderable. That is to say it does not seem to have any appreciable weight whatever. We should not expect sound, heat or light to have weight, for these are mere motions of particles, and a body does not become heavier when its internal parts begin to get into a state of vibrations or movement, any more than a clock weighs heavier when it is set going. But whatever electricity is, it is certainly not affected by gravitation.

There is also another remarkable difference between electricity and magnetism. If a body is caused to touch a magnet, the magnet is not weakened, its force is not taken away. Place a piece of iron in contact with it, and it even grows stronger rather than weaker. For though the iron seems a conductor and attractor, so to speak, of *lines of force,* yet it does not conduct away the magnetism. The only effect it has, is to alter the lines of force, and hence the action of the magnet for a time, but on the removal of the iron things revert to their previous state. But with electricity the case is quite different. It is not only capable of exerting force upon bodies at a distance, but is itself capable of flowing along all substances. The substances it can flow most easily through, are silver and copper. The other metals follow in a certain order, then come liquids of various kinds; then stone, earth, and wood; lastly ivory, glass, gutta percha, and ebonite or vulcanite (certain preparations of india-rubber and sulphur and other things, largely used in electrical apparatus). Certain liquids such as paraffin oil, and certain gums or soft substances such as paraffin wax, resin, and pitch, conduct so badly that they offer many millions of times the resistance of copper. Hence for all practical purposes they are termed non-conductors or insulators, and serve to keep the separated electricities apart, till they come to the time and place when they are to be permitted to rush together, doing their appointed work on the way. The conducting power of insulators, small as it is, is a defect in them, and causes "leakage."

The object of the electrical engineer, is, if possible, to produce and accumulate large quantities of electricity of opposite kinds, in conducting bodies, and then use wires to conduct them and insulators to guide them into those positions at which he desires they shall come together and disappear; and so to arrange the work they are to do, that they cannot obey their desire to rush together, by slipping aside into any byepath, but are compelled to take the path provided for them and to do the appointed work on the way.

Electricity in motion passes through the whole inside portions of conductors, but when it arrives at a state of rest, it distributes itself over the surface. Thus static electricity is never found in the interior of conducting or non-conducting bodies. It distributes itself regularly according to certain laws, over conductors; and over non-conductors it spreads in irregular patches, tending by degrees to become more uniform.

Electricity seems to possess some property akin to what we call "quantity." A quantity of electricity may be measured and divided into any number of parts.

It seems within certain limits indestructible, so long as its corresponding portion of negative or positive electricity is kept apart from it. But a certain definite quantity of electricity may have very different degrees of power stored up in it, like water which may be at the bottom of a well or at the top of a mountain. In the former case it could do no work, for it has no place to descend to; in the latter, it could rush down and turn a mill. Steam compressed in the boiler of a locomotive has immense work-doing power stored up in it, but when dispersed in clouds over the fields its work-doing power is gone. The same quantity is there, but its energy has been taken from it and converted into the motion of the train, the heat of friction, and other forces. So, a quantity of electricity if compressed or condensed into a body from which it cannot escape, is self-repellent, and tends to fly to the surface of the body, where it remains and stops, till it gradually leaks away through the supports by which the body is suspended. Now, if the size of this body is diminished, the electricity on it becomes more compressed, and hence acquires greater energy. Quite apart from any force necessary to compress the body itself, the mere electricity in it will oppose its being made smaller, and offer a resistance which requires energy to overcome it. And thus by compression, energy or work is stored up by making the electricity more energetic or powerful, just as a quantity of steam is more powerful to do work, in proportion as it is compressed into a smaller and smaller space. This power of work-doing, or "energy" of electricity as compared with its quantity, is called its potential, and is estimated in a rather elaborate way, with which the reader need not be troubled. Therefore in considering the work-doing power of electricity we must ask, what quantity is there? and what is its potential? And just as the work stored up in steam is indicated by its expansive force, so is the potential of a quantity of electricity measured by the violence with which it will fly out of the place it is in, if it can find an opportunity.

It may be useful here to note the difference between force and energy. Great confusion in popular language on this subject prevails, due to the fact that the true natures of force and energy were never fully understood till the researches of Professor Helmholtz and Mr. Justice Grove and others placed the matter in its true light. Force is a mere tendency to produce motion. Work is not done till the force is allowed to act by producing motion. A mere force, is a simple pressure. The weights of a clock when the clock has run down will pull as hard as before, but till they are wound up there is no energy stored up in the clock. The exertion of a force for any length of time performs no work unless motion ensues. A clock may be wound up, the weights may pull on the cords for years, but they will do no work unless the clock is set going. If a man were to press for an hour with all his force against a closed door, he would have done no work during that time, nor would he have expended any energy. He may be tired, it is true, but that is an accident due to his physical constitution. It would tire him to sit in a cramped position in a railway carriage for an hour, so that mere fatigue or bodily pain is no test of work being done. It tires a man to walk down stairs, but he is doing no work all the while. It tires him to support a weight with his outstretched arm, but the only work he does is in raising it. A pillar would support it for ever. A powerful magnet may exert an attractive force on a piece of iron for an indefinite time, but it has done no work, and lost no energy. In fact there is no energy stored up in a magnet. The only energy in a magnetised system depends on the attracting parts being at a distance one from another, and is yielded up if their parts are allowed to approach one another. A horse tied to a post, puts a strain on a rope that may last for hours, but it does no work in the process; nor could his strain work a machine, unless you allowed him to move on. Then, his dead strain would be converted into a moving pull, and he could go round and round and drive a mill. The confusion between these things led many persons to devise what they thought were perpetual-motion machines, which were designed to use a simple force as if it could do work without moving. Once this is understood, it at once becomes clear that a perpetual-motion machine is an impossibility, for you cannot drive a machine without work; you cannot have work without motion into successive *different* positions, so that the body never comes again to the position from which it started; which motion must sooner or later come to an end by the arrival of the body at its final position.

The work-doing efficiency of a quantity of electricity therefore depends partly on its quantity, partly on its energy or potential.

By "power" is meant the *rate* at which energy is being expended. One speaks of the power of an engine as that of so many horses, that is of so many foot-pounds of work *per second*, the work done by it, is the actual number of foot-pounds themselves.

SEC. 3.—*The Production of Electricity.*

There are very many modes in which electricity can be produced. Firstly friction, which is of no use to the lighting engineer. The next is chemical action, which was the means used prior to the invention of dynamos. Thirdly there is the use of magnetism, with which I will presently deal, and which is the present method. Lastly, there is the heating of joined pieces of metals, which also produces currents, and which will possibly be the mode adopted in the distant future.

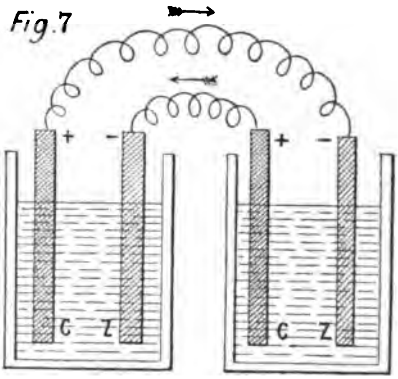
Page 166. The first mode of producing electricity, namely friction, is the method upon which those machines proceed which are commonly known as frictional electrical machines. The electricity developed by these machines is multiplied in some of them by means of various ingenious devices, but in the beginning it is produced by friction. The reason why friction produces electricity is not understood. Friction only succeeds in producing electricity when different sorts of substances or surfaces are rubbed together, when, on separating them, each of the substances is found to contain an equal quantity of an opposite kind of electricity. Thus if a cake of resin be stroked with the skin of a cat, the resin will be positively electrified, and the skin will contain an equal quantity of negative electricity.

The peculiarity of this kind of electricity is that its potential is enormous, but its quantity is infinitesimal. Hence, its work-doing power, though distinguished by great activity, is small. It will leap over great resistances in the form of sparks, or from cloud to earth in the shape of lightning flashes. It will produce great physical effects on the bodies of men, and even throw down buildings: but its quantity is so exceedingly small as to make it capable of doing but little regular work. Even if we could produce it in quantities sufficient to make it really useful for work, its potential is so enormous that it would be most dangerous and difficult to use. It would be like using gunpowder to drive engines instead of steam, a thing that has been successfully done, but is not adapted for common use. Therefore frictional machines and the electricity developed from them are rather objects of scientific interest than practical use. When, however, electricity is desired in a static condition, that is, when it is desired to collect it and keep it at rest on bodies, then this high potential electricity is very useful, for it enables us to experiment upon the statical properties of electricity by means which would yield no appreciable result unless the potential were high.

The next method of developing electricity is by chemical action. It has been found that when two pieces of different metals are joined together at one of their ends, the other ends immediately exhibit a difference of potential, that is to say, there is a tendency for the electricity on one of them to struggle to get to the other. But this difference of potential is so small as to be almost immeasurable; it is far smaller than the difference of potential produced by rubbing a stick of sealing wax with a silk handkerchief. If, instead of joining the metals, we separate them and place them partly in a conducting liquid, the ends which are out of the liquid immediately exhibit a difference of potential. If the liquid is not only a conductor, but also capable of acting chemically on one of them, then, when the external ends are brought together or connected by a wire, a continuous rush of electricity of low potential, but of immense quantity, takes place from one to the other. The electricity thus produced constitutes a current proportioned in its quantity to the metal decomposed by the liquid, and it is in its dynamic or moving condition that we shall in future consider it.

The means adopted are simple, but the reason of their operation is still a subject of dispute, or at best but imperfectly understood. To take an example, if a plate of copper and one of zinc, to which wires are attached, are immersed in a vessel containing sulphuric acid and water, the wires leading from the plates while still apart immediately show signs of being electrified, though the difference of potential is exceedingly small. This difference of potential is always the same for similar metals and a given strength of acid, no matter how great the plates be, or what their shape or distance apart. This difference of potential of the electricity at the ends of the wires is that which tends to cause the electricity to endeavour to rush from one wire to another; and when the wires are united the terminals are kept by the chemical action at a constant difference of potential, which in this case causes the electricity to continue to flow through them. As this difference of potential is of the nature of an impelling or driving force, it is called by the name of electromotive force, or is sometimes spoken of as "pressure of electricity," or written for abbreviation E.M.F.

Fig. 7



But though the electromotive force from such a cell is exceedingly feeble, the moment the wires are brought sufficiently near (which in general must be a distance of some 1-1000th of an inch), a small spark passes through the intervening air, and if the wires are joined (wire being a good conductor and air an exceedingly bad one), a continuous current passes along the wires, and from one into the other. So rapidly is this current replaced as it passes, that the quantity passing in at any time is enormous, though, as has been said, it is of low electromotive force. If the number of cells is now doubled, being joined in series, that is copper of one to zinc of the next, the electromotive force of the two cells is now double that of one cell, and so on for any quantity whatever. The cells may be microscopically small, or of uneven or irregular sizes, they may be of any metals, in any liquids, or some of one kind, some of another; the electromotive force of the whole system joined in series is the sum total of the eletromotive forces of each of the cells. The amount of current which will flow is dependent, as we shall presently see, on the size of the plates, their distance apart, and the thickness and nature of the various conducting wires; and if these are made large enough, the resistance will be indefinitely decreased, and there is no limit to what the strength of the current may be.

The cells in actual use are not of the simple nature above described, which are very feeble, and objectionable for several reasons, but are usually of the kind designed by Mr. Justice Grove, the earliest of all the improvements, and which remains the most powerful and convenient for producing light. Bunsen and others have also constructed cells of great power, which are cheaper to construct, and therefore much in use. This current thus produced will do work. To light a very small lamp six or eight such cells would suffice, a brilliant arc light can be produced from thirty to forty. From the foregoing description it would appear as though a perpetual energy machine had been designed, for power seems to be indefinitely produced. But this is not the case. As the current goes on, and in exact proportion to the current producod, the zinc and acid are wasted away and formed into products. The current will not flow unless the zinc is wasted, and the waste of zinc is an exact measure of the amount of current obtained. Here then is the source of the energy. The exact nature of the mode in which the zinc is made to give out energy is not understood; it is as mysterious as the mode by which fire causes coal to give out its heat. The fact exists; science is not at present in a position to explain the reasons of it. The nature of the chemical changes which take place is exactly known; why they take place, or how it comes that energy is yielded up in consequence, is at present an unsolved problem, though many ingenious guesses have been made at the truth. From these cells so enormous is the current, that considerable work may be obtained, though the electromotive force is so feeble that the current from a considerable number of them might be passed through the human body without any inconvenience.

It has been mentioned that as an experimental fact the electromotive force of a cell is always the same when the same metals and liquid is used, whatever its size, shape, or construction. There is, however, one particular cell which is of such great constancy and steadiness, that it is usually adopted as a standard of comparison, especially as its electromotive force happens almost exactly to coincide with the unit of electromotive force which has been selected. For practical purposes the electromotive force of a Daniell's cell may be considerd as the unit, and its electromotive force considcred as one volt. Hence, then, when we speak of a current as having an electromotive force of so many volts, we mean that whatever its quantity may be, its electromotive force is the same as would be got by joining up that number of Daniell's cells in series. The electromotive force of a Grove's cell is about double that of a Daniell, and hence is about two volts. The word "volt" was coined in honour of Volta, one of the discoverers of dynamic electricity. We next need a word and a unit to measure *quantity* of electricity. This is supplied from the name of "Coulomb," another great pioneer of static electricity, and we may speak of so many " coulombs " of electricity, just as of so many gallons of water. But we shall rarely deal with coulombs, for we are not concerned with electricity at rest, but with currents in motion. Hence it is usually more convenient to consider currents as being of such a kind that so many coulombs pass in a second. A current such that one coulomb of electricity passes in one second is said to be an "ampère" current, and here again the name of one of the founders of modern electrical science has been employed. Indeed it is impossible to deal in a static condition with the quantities of electricity which even a very small battery will produce. The whole earth and solar system could not hold in a static state at the same potential at which it was produced, the quantity of electricity which a galvanic cell pours out in a minute.* Suppose a Grove's cell placed in space, and joined at one terminal to the earth and at the other to the moon. In about a second, it would have poured into each of them so vast a quantity of electricity in a static state that the electromotive force between them would become two volts (*i.e.*, that of the cell). Then all action would cease, and unless the earth and moon were united by a conductor no current would flow. But unite them by a conductor, and at once you would get a current of so many ampères strength, dependent on the size of the cell, and the resistence of the wires and system.

Now the work-doing power of a current depends on two things, viz., on its strength (measured in ampères) that is the quantity that flows per second, and on its electromotive force (measured in volts). It varies directly with both of these. Hence, being dependent on both of them, the energy or work-doing power varies as the current strength multiplied into the electromotive force. If either varies, then the energy varies accordingly. If both vary, the energy varies with both of them.

" Energy" has also its measure, and a current of one ampère, with an electromotive force of one volt, is said to have a power of one " watt." To recapitulate, — a current of one ampère (that is, in which one coulomb per second is flowing), at an electromotive force of one volt, has a power or rate of energy of one watt; and if allowed to act for a second, will do about

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* There is an artifice known as a condenser or Leyden jar, by means of which the capacity of matter to hold electricity can be enormously increased.

.75 foot-pounds of work. We have seen that a Daniell's cell is approximately a measure of electromotive force.

A current of one ampère at an electromotive force of one volt, has a work-doing power of one watt. This is found by experiment to be about 1-746th of a horse-power. Hence a current of 746 volt-ampères, that is, of such a number of ampères, at such a number of volts as multiplied together makes up 746, is the equivalent of the energy of an ordinary working horse. Thus, if fifty Groves cells were joined in series, the electromotive force would be 50 × 2 volts = 100 volts. If the current given (which, as we shall presently see, would depend on the resistance of the wires and size of the cells, etc.), were (say) five ampères, then the power of the current would be 500 volt-ampères; that is, 500-746ths, or about 3-5ths of that of a horse. A strong pony would have such an energy, and either the fifty cells properly arranged, or the work of the pony applied to a dynamo, would give a small electric arc-light or light up some five or six incandescent lamps.*

It has been mentioned, that when a source of energy is taken, having a certain electromotive force, the amount of current which will flow from it through any conductor varies with the size of the conductor. This leads us to a consideration of electric resistance. Some bodies, as has been said, conduct electricity millions of times better than others, and at p. 178 is a table of the relative conducting powers of various substances as compared with copper, which is the conductor usually used for electrical purposes; for no other metal which conducts so well can be got for a reasonable price. For telegraph wires copper would be too dear, so iron is used, though it is a much worse conductor. By this resistance is meant the "want of conducting power." Resistance may be looked on as a sort of friction, wasting down the electric power just as a rough road impedes a carriage. If by the use of a powerful electromotive driving force you attempt to send a large current through a wire of great resistance, then a sort of equivalent of friction will come into play, and the wire will be heated perhaps to redness; or if for a wire we substitute a fine thread of carbon, we may get such incandescence as to produce an incandescent lamp.

As a rule, the flow of water through a pipe does not diminish directly with its length,—for it does but little work in flowing through the pipe; whereas electricity, in flowing through any wire, uniformly exhausts itself as it proceeds. If during its passage the motion of the water in the pipe were gradually and uniformly reduced, and its stored-up work gradually taken from it, till when it flowed from the other end there was no work whatever left in it, then the amount of work done in any such pipe would vary with its length. This is true of electricity: the resistance of a wire of any section varies directly with its length.

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* In future, instead of dealing with electricity of two kinds, we shall suppose that there is but one flow of electricity from positive to negative, and this is what is meant by a current.

The capability of a wire to carry a current increases in a direct ratio with its sectional area, and diminishes in proportion to its length. (The first it was natural to expect, for the capability of a pipe to carry off water varies with its size.) The resistance of a wire therefore depends on three things,—

(1) On the metal of which it is made, being large for platinum and small for silver;
(2) Its sectional size, being greater as the area of the cross-section is diminished, that is, in inverse proportion to the square of the diameter;
(3) Its length, being greater in proportion to the length of the wire.

From these laws, given the resistance of a certain piece of wire, we can calculate the resistance of any other of any given size and the same material. For winding electro-magnets and for electrical purposes generally, copper wire is used of very good quality, as very slight adulteration greatly impedes its conducting power. This wire is sold in sizes according to a wire gauge (usually the Birmingham system). It is covered with silk or cotton, or gutta percha; sometimes it is double wound, the better to resist accidental abrasion. Silk is preferred, as a thinner covering is of the same effect as a thicker one of cotton. Gutta percha is too thick for winding coils. For conducting cables a cheaper covering of tarred tape is commonly used. Where electric potential is small, as when it is under 100 volts, the connexions must be very close and the wires well soldered together; for such "low-pressure" electricity has not a great power of leaping over spaces. On the other hand, the same property makes it quite safe to attach the bare wires to woodwork; for, whereas static electricity on a conducting body must, on account of its high potential, be very carefully insulated even from far inferior conductors, dynamic electricity of low potential has no great electromotive force tending to drive it away into other bodies to which the conductor which contains it is attached.

For various reasons, which it is unnecessary here to discuss, the standard of comparison for resistances has been determined to be the resistance of a column of mercury 1062·14 millimetres (41.782 inches) long, and of one square millimetre (.00154 square in.) cross area, at the temperature of freezing water. This is equivalent to a piece of round copper wire one-tenth of an inch in diameter and about 960 feet long. It has been so arranged as to bear a relation to the ampère and volt of which I have spoken, and if an electromotive force of one volt were applied to send a current of electricity through a wire one-tenth of an inch in diameter and 960 feet long, the current which such a force would be capable of driving through such a wire is one ampère (*i.e.*, one coulomb per second). This standard of resistance is called an "ohm," after another celebrated electrician. If we wished to drive double the current through such a wire, we should have to employ double the electromotive force. If we increased the resistance of the wire to double as much, then to keep up the current we should also have to double the electromotive force; and in general it may be said that the current which a given electromotive force is capable of driving through a wire, is directly proportional to the electromotive force, and inversely proportional to the resistance. The more nearly this law is tested by experiment, the truer it seems. It is known as Ohm's law, and is the fundamental principle of the arrangements of lamps and circuits for electric lighting. Expressed in symbols it stands thus:—

> The amount of current which a given electromotive force can drive through a circuit of a given resistance, is directly proportional to the electromotive force, and inversely proportional to the resistance, or
>
> C (strength of current in ampères) =
> E (electromotive force in volts) $\div r$ (resistance in ohms)
>
> $$\text{thus } C = \frac{E}{r}$$

An electromotive force of one volt (*e.g.*, about that which a Daniell cell would produce) driving electricity through one ohm resistance (*e.g.*, 960 feet of copper wire one-tenth of an inch diameter) will produce a current of a strength equal to one ampère. Such a current as this, at such an electromotive force, through such a resistance, would give, as may be easily guessed, a very poor result in lighting, the energy being about sixty times too small to light a twenty-candle incandescent lamp.

TABLE OF RESISTANCES OF PURE COPPER WIRE.

Birmingham Wire Gauge.	Diameter in Inches.	Diameter in Millimetres.	Area. Square Inches.	Weight. Pounds per Mile.	Resistance per 1000 Ft. in Ohms.	Resistance per Mile in Ohms.
No. 1	.300	7.62	.070	1438	.114	.605
,, 5	.22	5.58	.038	773	.213	1.126
,, 10	.134	3.40	.014	286	.574	3.035
,, 12	.109	2.77	.009	190	.868	4.587
,, 14	.083	2.10	.005	110	1.498	7.912
,, 16	.065	1.65	.003	67.5	2.443	12.90
,, 18	.049	1.24	.001	38	4.299	22.70
,, 20	.035	.889	.0009	19.6	8.427	44.49
,, 22	.028	.712	.0006	12.5	13.16	62.52
,, 24	.022	.558	.0003	7.7	21.32	112.6

The following formula will enable the resistance in ohms, the length in feet, or the diameter of a wire in inches, to be found, if two of the factors are given.

$$R = \frac{.00001025\ L}{D^2}\ ;\ \text{at } 60^\circ \text{ Fahr.}$$

Or, in other words, 1000 feet of round wire one-tenth of an inch in diameter has an approximate resistance of one ohm. The resistance of copper diminishes about .20 per cent. for each degree Fahrenheit of temperature above 60 degrees, and increases about .20 per cent. for each degree below it. The resistances of other metals are as follows:—

Silver	.94 times as much as copper.
Gold	1.3 ,, ,, ,,
Zinc	3.5 ,, ,, ,,
Platinum	5.7 ,, ,, ,,
Iron	6.4 ,, ,, ,,
Lead	12.8 ,, ,, ,,
German silver ...	14 ,, ,, ,,
Mercury	59 ,, ,, ,,

SEC. 4.—*Electro-Magnetism.*

From the previous considerations we have now seen that the great desideratum in the production of electric currents is a good electromotive force, driving a large quantity of electricity through a small resistance. With static electricity we have nothing to do. A practical engineer cares nothing for engines at *rest;* he is only concerned with them when in motion. Motion, as was shown above, is necessary to the doing of *work,* and so the practical electrician is concerned entirely with moving, and hence work-doing, electricity.

We have investigated the second mode of producing electricity, viz., by chemical action. We now proceed to the third method, viz., by the use of magnets. At first, magnetism and electricity were independently discovered. No connexion was seen to exist between them. In the last century some daring speculators, actuated by the true spirit of philosophy which seeks to find relations and connexions everywhere, imagined that they might be related, and tried experiments, but failed. They sent currents through masses of iron, but they did not become magnetic; they connected magnets by wires, but no currents flowed; until, in 1819, Oersted fortunately discovered that an electrical current flowing through a wire attracted a magnet, and *vice versâ*. This was followed, in 1820, by the discovery that electricity, when properly employed, was capable of causing magnetism in iron, and finally, by the discovery of Faraday, in 1820, that magnetisation was capable of producing electricity. The relationship of magnetism to electricity was thus established. We shall proceed to examine the manner in which this can be done, premising, however, that the whole subject is at present but imperfectly understood, and that the practical electrician is safer in relying on *facts*, rather than on theories.

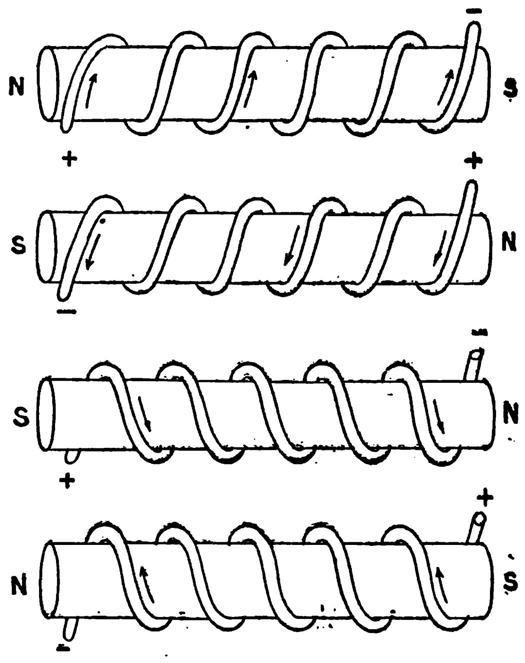


Fig. 8.

When currents of electricity run round iron, they convert it into a magnet, and conversely magnets, moved in proximity to wires, cause currents of electricity to flow through them.

But of all the various laws that have been discovered, two only are essential to the comprehension of dynamo machines. The first of these is as follows :—"If a current of electricity run round a piece of iron, the iron becomes converted into a magnet, with the poles as shown in Fig. 8. Now, all these four cases shown in the figure are only variations of one single law, that when a current runs round a piece of iron in the direction of the hands of a watch, as it would if the coil were twisted round the rim of the watch, the part of the iron corresponding to the face of the watch becomes a south pole, and that corresponding to the back, becomes a north pole. Or again, if a current runs down a corkscrew from the handle to the point, a piece of iron placed in the spiral of the corkscrew will become a magnet, having its south pole towards the handle, and its north towards the point. Or again, if a current of electricity were going round the earth

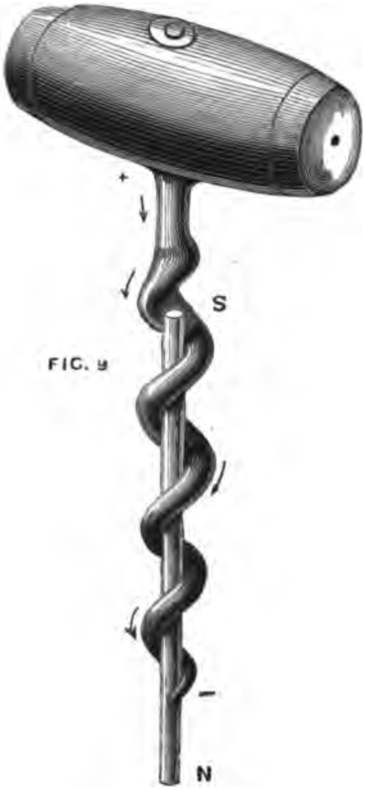


FIG. 9

in the direction of the daily motion of the sun from east to west, it would make a magnet of the earth with poles in the same position as they now are, viz., a north-attracting pole (*i.e.*, a true south pole) at the polar regions, and a south-attracting (or true north pole) at the southern polar regions. Magnetically considered, the north pole of the earth is a south pole, and *vice versâ.* It does not matter whether the coil round the magnet is wound upwards or downwards or backwards and forwards in several layers one upon another, the only matter of consequence is, whether the current goes round from right to left, or from left to right. Thus, in making an electro-magnet, the coils may be wound from one end of the iron to the other and back again, and so backwards and forwards like cotton thread upon a spool, the direction of the winding being kept unchanged. On sending a current through such a wire, the iron becomes magnetic, or as it is called, an "electro-magnet." The process is almost instantaneous, and is accompanied by a faint " click " in the iron which indicates some internal change. During the process of converting the iron into a magnet, work is done, but as soon as it is converted, no more work is needful. The magnet does no work by remaining a magnet, and no difference is made in the current after its first short effort is over. When the current ceases, the soft iron instantly ceases to be magnetic, and the small energy which before was expended in making it a magnet is returned in the shape of a very small current in the wire.

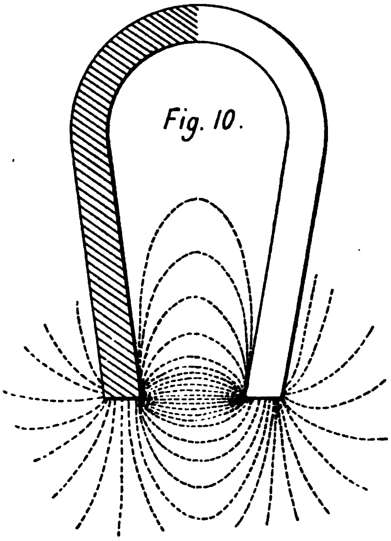
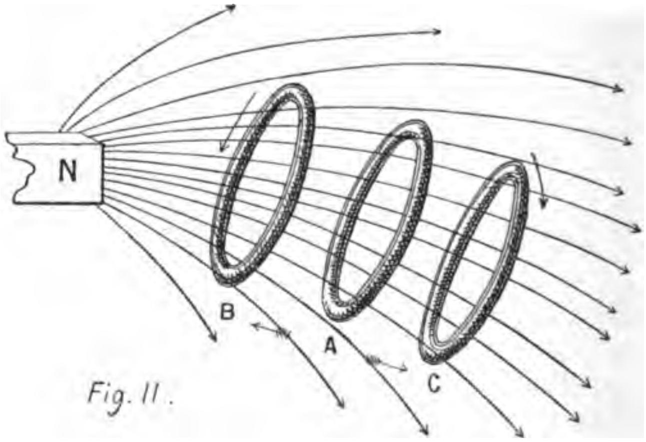


Fig. 10.

But if instead of a piece of iron we had a piece of tempered steel, after the current ceased, the steel would still retain considerable magnetism, and become a permanent magnet. This is one of the methods by which permanent steel magnets are made. Permanent steel magnets are, however, not only feeble, but uncertain in their retention of magnetism. They vary somewhat in strength from time to time, and heating to redness will deprive them of their magnetism. The more they are used, the more force they are made to exert, the stronger they become. They are frequently made in the shape of horseshoes, so as to bring the poles together, and thus get strong and intense fields of force.

Horseshoe magnets should be hung up by the middle, and a soft iron armature or bar placed on to the poles with as heavy a weight as the magnet will bear. Under this treatment the magnet will improve by the constant exertion of force. As has been said before, no work is being done by the magnet in sustaining the weight.

The second of these laws is as follows:—Let a closed conducting wire circuit of any shape, such as a ring, be placed in any position in any field of magnetic force so that some lines of magnetic force go through the space enclosed by the ring. So long as the ring remains at rest, no electric current is induced in it. But let the ring be moved, then, in *almost* every conceivable position in which the ring can be placed, this movement will cause the number of lines of force enclosed by the ring to become either larger, as in motion from A to B, or smaller, as in motion from A to C. (Fig. 11.) If the ring is moved in such a manner as to lessen the number of lines of force going through it, then while such lessening is going on, as in motion from A to C in the



direction of the feathered arrow, a current of electricity is generated in the ring in a direction shown by the featherless arrow, which current ceases directly the motion stops. And conversely, the motion from A to B causes an increase in the number of lines of force traversing the ring and a current in the reverse direction as shown by the featherless arrow near the ring B.

A great variety of examples might be given showing various kinds and shapes of circuits, or rings placed and moved in various positions in various sorts of fields of force, but the foregoing law is universal, and is true whether the motion of the ring be longitudinal or sideways, or forward or backwards, or whether the ring be spun round on its axis. The sole condition of its movement producing a current is that the wire composing the ring, shall cut lines of force in such a way that the number entering the ring is either increased or diminished. The ring could no doubt by a careful arrangement, be made to go in such a manner that though numbers of lines of force were cut by it, yet just as many were lost on one side as were gained on the other, thus the total would be neither increased nor diminished; in such a case no current would flow.

The matter may also be considered in another light. Suppose a ring is made of a long piece of wire, the ends A, B of which are fixed and joined together so that the wire can swing on the axis A, B as on a hinge. Let the middle part of the wire be moved across the lines of force of a magnet. Then it is clear that as the fixed side of the ring being stationary cuts no lines of force, the increase or decrease of the lines of force passing through the ring will depend on the number cut by the part of the circuit which is in motion. We may now consider what the effect is, of the motion of any portion of the wire, such as *a b*, Fig. 12, in the direction of the feathered arrow. As this portion cuts lines of force, then so far as it is concerned, a current is generated going from *a* to *b*, as shown in Fig. 12.

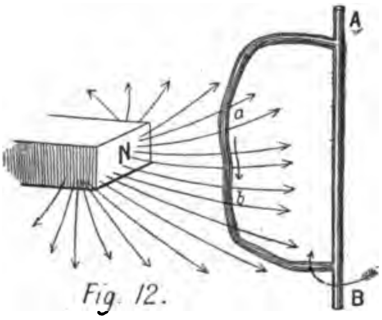


Fig. 12.

The direction in which the current is generated will of course depend on the direction of the lines of force which are cut. The following rule may be useful for recollecting in a practical manner the directions in which the currents will flow. Let the north pole be supposed to radiate lines of force, as the rose-nozzle of a garden watering-hose radiates streams of water. These streams rush out in all directions, widening as they go. Sometimes they go nearly straight, sometimes the wind catches them and twists them into all conceivable forms. Now let a man made of copper walk along in any path he chooses, whether straight or curved; and let the water play upon him in any position from below or from a height, or at any distance. Then if the spray of water strikes him full in front or full behind, no effect is produced in him; but if the spray strikes him anywhere on the left hand, it causes a current to run from his head to his feet, if on the right, to go from his feet to his head: always supposing that he goes face forwards along the path he is pursuing. The adjoining diagram, Fig. 13, will show this.

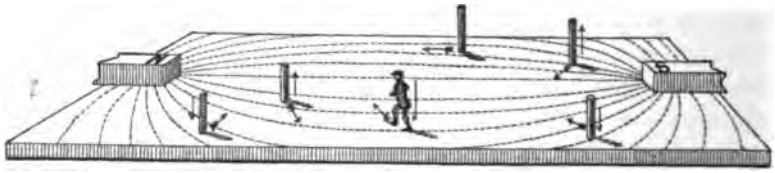


Fig. 13.

The lines of force of course radiate in *all* directions from a

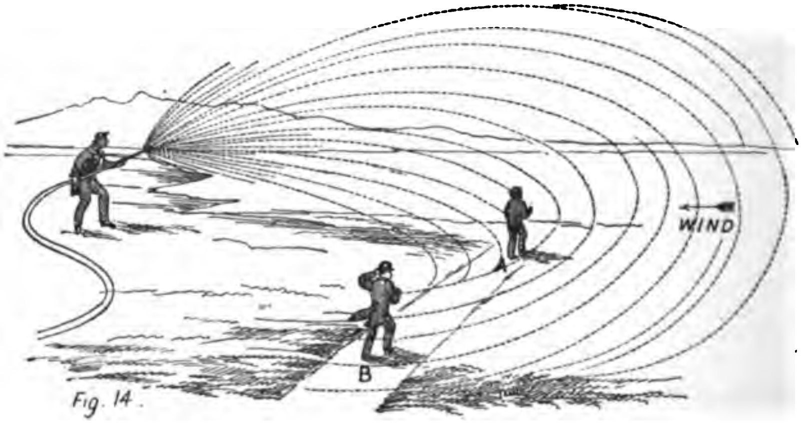


Fig. 14.

Illustrating the effect of lines of magnetic force radiating from a point but twisted and curved in various directions by external influences.

magnet, but for simplicity we may only consider those lying in a horizontal plane, as shown in the figure, the currents flowing in the directions shown by the featherless arrows, the motions as shown by the arrows with feathers.

Fig. 14 may also assist to make this clear. The man at A has a stream on his left hand as he walks, and a current goes from his head to his feet, but the man B is only affected by a stream which, though it starts from a point on his left, yet is curled round by the wind so as to fall on his right, and hence the current goes from his feet to his head. Thus the effect of the motion of any part of a circuit may be calculated. The total effect is found by reckoning up all the effects of the various parts owing to the motion of the whole circuit. The currents may be such that some go in one direction, some in the opposite, in that case the total effect produced is the difference of the effect of the various parts.

Let us consider a few more examples :—Let a ring, A, move into the successive positions, B, C, D, E, F, G, in the directions of the feathered arrows, passing lines of force proceeding from N to S; then currents will be produced as shown by the featherless arrows from A to E, at which point the current will be reversed and go in an opposite direction, during the passage of the ring from E to G; for during the passage of the ring from A to B the number of lines of force passing through it are evidently increasing, and this increase goes on till the ring gets to C. In the passage from C to D the increase still continues, for now that the magnet penetrates the ring, all the lines of force which exist within the

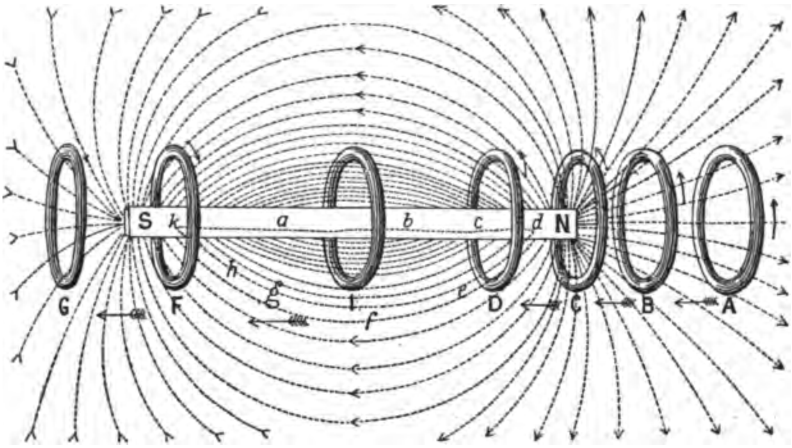


Fig. 15.

body of the magnet, and run from south to north inside the magnet, pass through the ring. At D almost all the lines of force of the system pass through the ring. The only ones that do not are some which, like A, B, C, D, E, F, G, enter it, but turn sharp round, and, as it were, sneak back to the south pole without threading the ring. At E the maximum of lines obviously goes through the ring. During the passage from E to F the number of lines going through the ring obviously diminishes; and at G only those coming in from the left hand go through it. From E to G the number of lines of force passing through the ring obviously diminishes, and the current is as shown by the featherless arrows. For it must be remembered that only the lines of force which thread through the ring and round on the outside of it count: those which merely go in and out again count for nothing, undoing by coming out in one direction any good they have done by entering in the other. They cannot be called lines passing through the ring at all.

Or, again (Fig. 16), let a ring travel from A to the successive positions B, C, D, E, presenting its end to the pole, N. Then, as the left-hand sides of the rings cut the lines of force, currents will be produced downwards, as shown by the large featherless arrows; but the right-hand sides also cut the lines of force, tending to produce currents also running downwards, that is, in an opposite direction round the ring. But these latter currents are feebler than the first, because the magnetic field is stronger on the left side of the ring (nearest the magnet) than on the right. Hence the total effect will be a current in the direction of the large featherless arrows; for the left-hand side cuts more lines of force as it goes than the right, the lines of force being closer as they are nearer the pole.

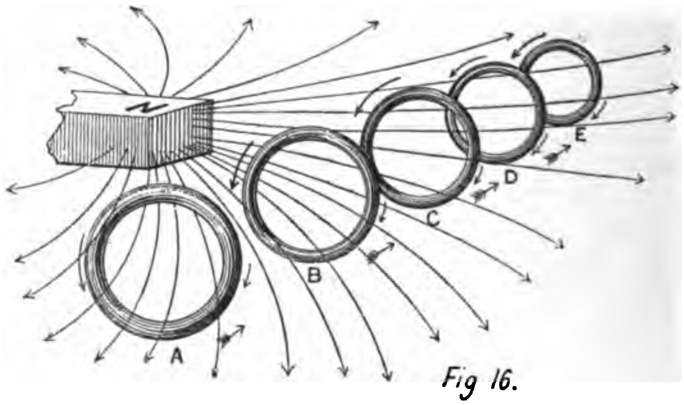


Fig 16.

Or, again, let a ring pass sideways in front of a magnet pole, as in Fig. 17, just as a hoop would be trundled along the path A, B, C, D, E, then the currents generated go as the featherless arrows show. Now, during the path from A to B, the current indicated by the arrow A on the hindermost side of the ring will be weaker than that indicated by B on the foremost side of the ring, which is in a more intense field, being nearer the magnet. Hence the total effect will be that of the arrow *b*, and the total current will be in the reverse direction to that of the hands of a watch whose face is towards the pole N. But when the ring gets to its middle position, D, just opposite the pole, the current indicated by the arrow on the hindermost side now becomes the stronger, and hence the total current is reversed.

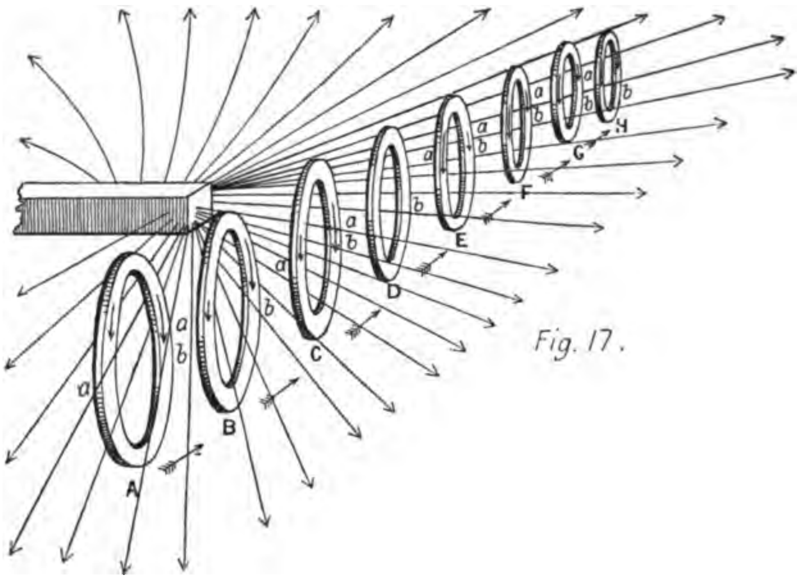


Fig. 17.

From this we learn that in general a ring sliding laterally past a magnetic pole, as in Fig. 17, reverses current on passing it; but if it goes towards the pole end on, as in Figs. 15 and 16, it does not reverse current in passing the pole, whether it slides over it or past it. And a corresponding observation is true when a ring passes the neutral or centre points of a magnet. In this case it is the ring that is travelling "end on," or in the direction of its axis, that has a current of changed sign as it passes the neutral point; whereas the ring sliding laterally does not undergo a reversal of current as it passes a neutral point. And we shall presently see that the currents in different dynamo-machines can be solved by an attention to these principles: this is made clear by Fig. 18.

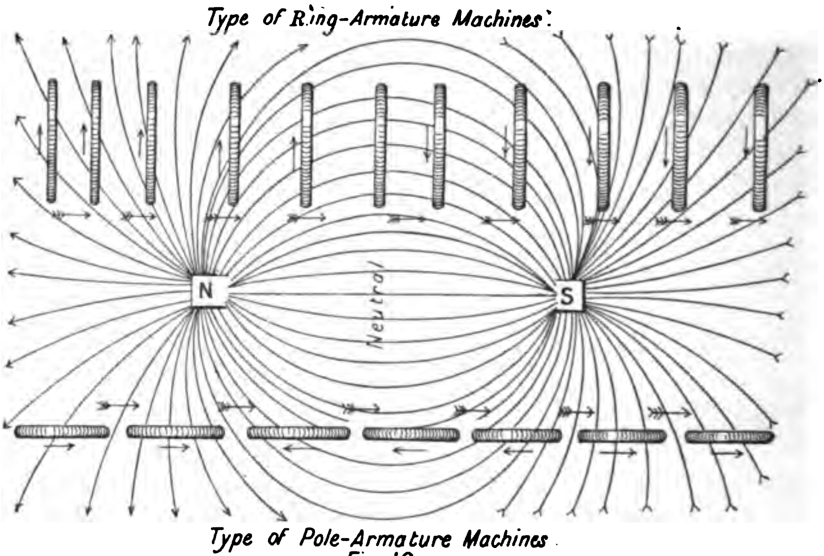

Type of Ring-Armature Machines.
N
Neutral
S
Type of Pole-Armature Machines.

Fig. 18.

There is also another easy way of recollecting the directions in which currents will flow in a coil cutting the lines of force of a

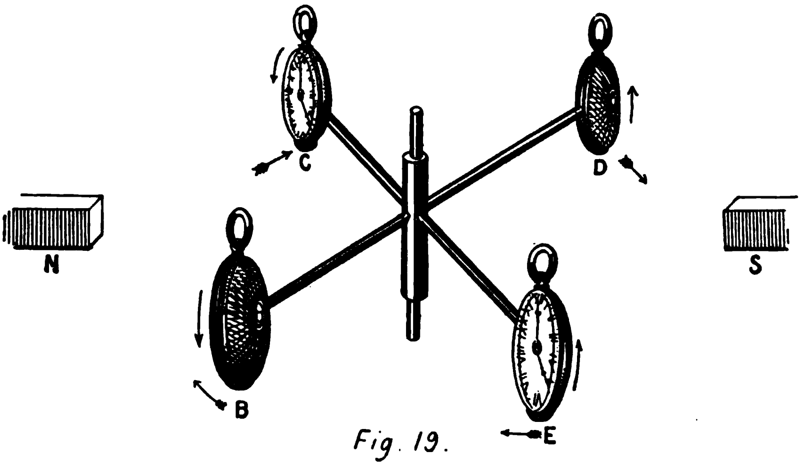


Fig. 19.

magnetic field. Let the coil be supposed to be wound round the rim of a watch, so placed that the lines of force proceeding from the north pole towards the south pole, pass the watch, entering the face of the watch, and coming out at its back. The face of the watch being supposed to be reversed if necessary when the direction of the lines of force changes by reason of the new positions into which the watch comes in its movement with regard to the lines of force. Then if the movement causes the number of lines of force passing through the face of the watch towards its back to diminish, a current will be generated in the coils in the direction in which the hands of the watch move, and *vice versâ*. Thus, if a coil, Fig. 20, were placed at the end of a radial arm

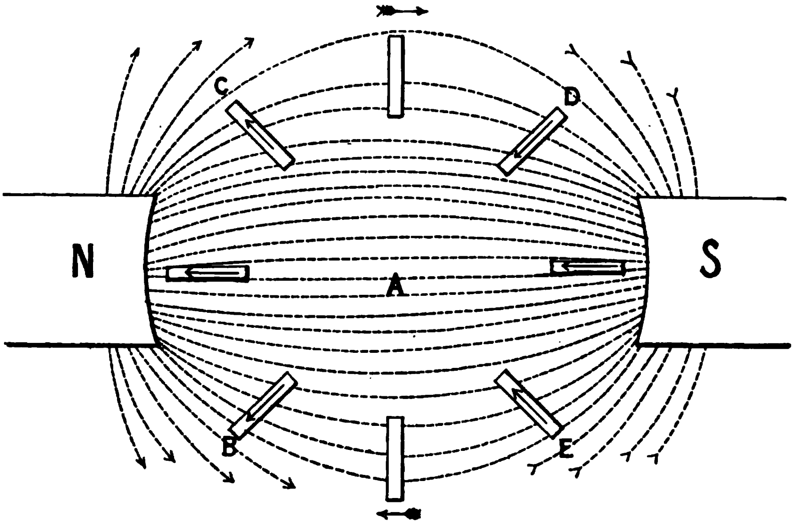


Fig 20.

A, B, and rotated into the positions C, D, and E. From B to N the watch would be turning sideways towards the pole N, and the number of lines of force passing through it, would be diminishing, and the current would be as shown by the featherless arrow in the direction of the movement of the hands; when it got opposite N it would present its side towards the pole N, and no lines would pass through it. When it got past N to C, the number of lines would increase as its face got turned more and more towards the pole (the face of the watch being now supposed reversed, in order that the lines of force shall still pass through its face), the current would now go in a direction opposite to the hands of the watch in its new position, which direction, however, an inspection of the featherless arrow will show to be in the same direction through the wire coils as before. From C to D there will not be much current generated, for while the receding movement of the coil causes the number lines of force passing through it to diminish, its turning or twisting movement rather tends to cause them to increase, so the total number will not change much. But when we get to D the lines of force passing through the face will begin rapidly to increase again, and a current would be produced as shown by the featherless arrow at D; and this current would go on till the coil got opposite S, at which point the face of the watch must be supposed to reverse (to keep its face towards the north pole), and then, as it moved from S to E, the lines of force constantly increasing by reason of its turning movement, would send a current in the reverse direction of the hands, that is, as shown by the featherless arrow at E. The current will thus reverse its direction at points midway between E and B, and between C and D. A reference to Fig. 20 will help to make this clearer, by showing the increase and diminution in the lines of force cut. The small arrows without feathers on the tops of the coils mark the direction of the currents, which will flow in the same direction as the coils move in the direction P, B, N, C, Q, and in the reverse direction as the coils move in the direction Q, C, S, D, P.

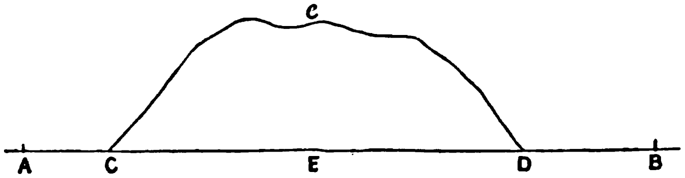
The case here explained is (with certain modifications to be hereafter considered) that of a Gramme ring, the foundation of the Brush, Maxim, Bürgin (or Crompton) and almost all machines of the "ring" type; its careful study is therefore of great importance. The modifications alluded to will presently be seen to depend on the fact that the coils of a Gramme machine have iron cores, which greatly modify the directions of the lines of force, thus causing more of them to be cut as the coils move round, and in a most ingenious manner giving greater efficiency to the machine.

In all these examples the lines of force have been presumed to go from the north to the south. These lines are, however, as has been said, like the watches, and probably also the currents themselves, mere fictions of the imagination, needed to enable us to comprehend the action of mysterious powers whose nature is unknown as yet. We might just as reasonably have supposed the current to flow from the negative or zinc pole to the positive or copper pole of the battery; and just as reasonably have supposed the lines of force to go from south to north. Or we might have imagined double currents and double sets of lines of force. It is, however, easily seen that some settled plan facilitates matters, and the above notation is that in common use among electricians. Experiments have been made to try and discover whether the current really flows from positive to negative,—that is, whether, when a current begins to flow along a wire, the effect is really perceived at the positive end before it is perceived at the negative. These experiments lead to the belief that the effect is simultaneous; but, owing to the enormous rapidity of the flow of electricity, they have not been very conclusive.

It has been said that when a given electromotive force is used to drive electricity through a wire, the current varies as the resistance. It remains to add, that if, instead of one wire, a number of different sized wires were put on end to end, the resistance, and hence the current, would vary with the sum total of the resistances of all the wires. If, however, the wires were arranged parallel to one another, then the current would have more than one channel; its total amount, therefore, would be more than when only one wire was employed. Thus, if two terminals, at which the electromotive force is kept constant, say at 100 volts (a very proper amount for an incandescent light dynamo), are united by 3902 feet of copper wire, one-fifth of an inch in diameter, the resistance would be about an ohm. At this rate the amount of current which would flow would be $C = \frac{E}{r}$ or $= \frac{100\text{ volts}}{1\text{ ohm}} = 100$ ampères. If the length of the wire be doubled, r becomes = two ohms, and the current would thus become only 50 ampères. But if the second wire were put on parallel to the first, or if, what is the same thing, the wire were made of twice the sectional area, then the resistance would only be half an ohm, and the current would become 200 ampères. These laws are the same for all kinds of resistances, whether of wires or lamps; thus, if we were to put, instead of these wires, two Swan lamps of say 30 ohms resistance each when hot, arranging them *in series*, the current would then become $\frac{100\text{ volts}}{60\text{ ohms}} = 1.6$ ampères at an electromotive force of 100 volts, or as there are two lamps *in series*, of 50 volts per lamp, which would be more than enough for the lamps, and would make them each give a light nearly equal to twenty-five candles. If, on the other hand, the lamps were placed in parallel arc or side by side, then if the electromotive force were kept the same, the current would now become $\frac{100\text{ volts}}{30 \div 2\text{ ohms}} = 6.6$ ampères, that is, 3.3 ampères through each lamp, at an electromotive force of 100 volts, which would destroy them. In the latter case the energy expended would be six times as great as before, and the engine would have to work nearly six times as hard to keep up the current. But more will be said on this point hereafter.

Although, as has been said, the electromotive force between different points of the circuit varies, being in general greatest between the terminals of the dynamo, the current, or amount of electricity running round the circuit, is always the same. Here, again, the analogy to the flow of water helps us. For, as a river flows on, the head of water and the violence of its rush may change,—now it may be a torrent, or again spread into a lake,—but the *total quantity* of water is unchanged: it is indestructible, and what goes in at one end must come out at another,—so with quantities of electricity.

When a wire is joined up in parallel circuit with a wire through which electricity is passing, a portion of the current will be diverted or "shunted," as it is called, through it. Thus, C *e* D is a shunt to the wire C E D. The addition of the shunt will lessen the total resistance between C and D, for there is an additional channel offered to the electricity. The proportion of the current thus shunted will be inversely as the resistance of C *e* D to C E D; or, in other words, the amount of current which takes the path C E D is to the amount of current which takes the path C *e* D, as the resistance of C *e* D is to the resistance C E D. Hence the thinner and longer the shunt wire, the less current will it abstract. In using incandescent lamps the usual plan is to shunt them. As the twenty-candle lamps, having a resistance of 30 ohms, require an electromotive force of about 46 volts, with a current of 1.3 ampères, if you have a machine having an E. M. F. of, say, 140-150 volts, you would join the lamps in shunted series of three, as in Fig. 21. The electromotive force would thus be about 46 volts per lamp. The resistance of each group of three lamps would be three times that of one lamp, or about 90 ohms. The amount of current required would be 1.3 ampères for each group of lamps, since the current would be split up into as many parts as there



were shunts. Hence, if we had to light 10,000 lamps so arranged, that is, if we had 3,333 of such shunts, the dynamo would have to be driven so as to give a current $= 3333 \times 1.3 =$ 4332 ampères, at an electromotive force of 140 volts. Whence

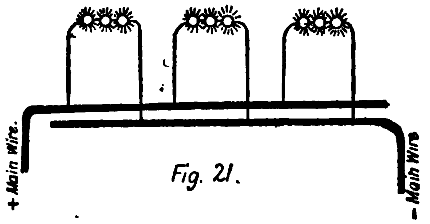


Fig. 21.

the energy of such a current would be 4333×140 volt-ampères $= 606,606$ volt-ampères. A good dynamo to give this result would need a driving force equivalent to from 1,000 to 1,200 horse-power in the cylinders of the engine, according to the efficacy of the dynamo. For the best machines give about 600 volt-ampères per horse-power, which would light about ten twenty-candle lamps, each requiring 1.3 ampères at 46 volts, *i.e.* $(1.3 \times 46) = 60$ volt-ampères. The actual theoretic value of a horse-power in volt-ampères has been calculated to be 746 volt-ampères. Few dynamos give more than 600 in actual practice, per indicated horse-power of the engine.

From these considerations it appears that a given rate of energy or work-doing power may be derived either from a large current at a low electromotive force, or from a small one at a high electromotive force. Static electricity, as has been pointed out, is usually employed in very minute quantities at a high E.M.F. Dynamic electricity in currents of comparatively enormous quantity at low E.M.F. The power of overcoming resistance depends on the E.M.F.; hence insulation becomes difficult in proportion as the E.M.F. is high. A conductor charged with static electricity requires to be insulated with long glass rods, surrounded by trays of sulphuric acid, to remove any film of damp which may settle upon them, while, on the other hand, a current of electricity, such as usually proceeds from a dynamo, will pass along a wire nailed to a wooden wall. This is a great convenience in Electric Lighting, and accordingly almost all electric connexions in practice are mounted on dry wood, well varnished, which is in general an amply sufficient insulation.

The human body has a very high resistance as compared with metal; hence a considerable electromotive force is required to drive a sufficient current through it, to do much harm. A direct current of even 200 volts will do no serious damage, but where the current is alternating, and thus gives a series of shocks in rapid succession, even 150 volts becomes very painful. Of course a great deal depends on whether the hands touch the metal conductors so as to make good contact. If the hands are dry, but little current will pass; but if the hands are wet with water, or with salt or acid and water, which is a good conductor, a much more severe shock will be received.

Accidental shocks are usually obtained by touching some wire with one hand. The current rushes into the body and finds an exit through the shoes into the earth, which it traverses and returns to the return wire. If all return earth circuits were completely avoided, and all the wires and dynamo perfectly isolated, of course the return of the current would be impossible and no shock would be received. Hence, with high electromotive forces, earth circuits are usually avoided as much as possible, and if the operator stands on a *dry* board, or, still better, on an india-rubber mat, or wears lawn-tennis shoes with india-rubber soles, the circuit will not easily pass through his body. Almost all serious accidents have happened through persons standing with damp shoes on a wet or damp floor, or on the iron of some machine.

I am not aware whether experiments have been made to determine the laws according to which currents flow through the human body. If they follow Ohm's law, which seems most probable, then to determine the current we ought to know the resistance. According to some experiments, at which I have assisted, the resistance of the body (apparently chiefly due to the skin) appears very variable. We did not make very extensive investigations, but the average resistances appeared to be about as follow:—

	Ohms.
Resistance between the two hands immersed to the wrist in acidulated water	2000
Hands wet with water holding conducting wire	6000
Dry hands ,, ,, ,, ,, ,, ...	25,000
Resistance between dry hands grasping a conductor, and the feet in dry boots without nails, placed on a grating of iron in circuit	50,000

According to these results, a man grasping with dry hands the conductor of a high-tension brush machine, 800 volts, would have a current of $\frac{800}{25.000}$ ampères, or an energy $= \frac{(800)^2}{25.000} = 25.5$ volt-ampères passing through him, or, with wet hands, 107 volt-ampères. The first of these represents nearly one-thirtieth of a horse-power energy; and the latter is one-seventh of a horse-power, or more than the whole work expended in a twenty-candle Swan lamp at incandescent heat. Either of these would probably be fatal. An alternating current produced through the dry hands of 150 volts will be found sufficiently strong in general to be somewhat unpleasant. This will produce a current of energy equal to one volt-ampère. As a general rule an alternating current of more than 200 volts, E.M.F., or a direct one of more than 350 volts, is not desirable. In these cases the wires, if touched with wet hands, would probably give an exceedingly severe shock. The shock got from a Leyden jar, at a very high E.M.F., would of course also be instantly fatal were it not that the quantity of the electricity passing is so infinitesimal that the energy is very small.

The effect of a current of electricity on a living body seems to be partly to decompose the tissue and partly to affect the nervous system. Accordingly the rigor mortis, or stiffness of death, which in some manner depends on the stage of decomposition which the body has reached, is of much shorter duration in animals killed by electricity, as is also the case when the animals have been hunted to death. It is also said that freshly-killed meat may be rendered tender by an electric shock, which causes the rigor mortis to have a very short duration, just as when animals are hunted to death. But the effect of the current on the nervous system is probably more dangerous to living beings than the work done in decomposing their tissue. For violent shocks so affect the nerves as to arrest the action of the vital organs, and it seems that these nervous effects depend, not only on the current sent through the body, but on the making and breaking of the current. A current which is quite imperceptible when continuous, becomes exceedingly painful when intermittent, and almost insupportable when alternate. Thus, in a good continuous machine, where the flow is almost perfectly uniform, no effects are felt. The current from the Edison machine cannot be felt though the two hands are placed on the brushes. But if the commutators were further asunder, so that a greater interval of time were left between each successive flow of electricity, the shock at the same E.M.F., viz., 53 volts, would be very disagreeable. This is one of the reasons why some continuous current machines of low E.M.F. are so much more painful to touch than others. All alternating current machines give a much more perceptible shock than direct current ones, even when the current is ever so intermittent. Drawing-room machines, meant to give shocks, are purposely provided with small contact breakers to increase the effect above mentioned, and small secondary coils give a terrible shock in proportion to the energy they afford, by reason of the complete make and break of the alternating currents from the secondary wire.

CHAPTER II.

SEC. 1.—*On Dynamos in General.*

I do not here propose to relate the history of the discovery of dynamo machines, nor to deal exhaustively with those which exist. I shall simply describe the leading machines which are at present in the market.

All existing dynamos may be divided into three main types :—

1. Those founded on the system of which Professor Holmes was the most celebrated exponent, viz., coils wound on cylinders of iron attached to the circumference of revolving wheels.
2. Those founded on Pacinnotti's plan (afterwards perfected by Gramme), and consisting of coils of wire wound upon an endless iron ring.
3. Those of which Dr. Siemens' machine is the type, viz., coils of wire wound lengthwise round a revolving iron drum or cylinder.

Of the first type are the machines of Mr. Gordon (Telegraph Maintenance and Construction Company) and of M. Lontin (Clark, Muirhead and Co.); of the second are the Gramme (British Electric Light Company), Brush, Schückert (Anglo-American Brush Company), Bürgin (Crompton and Co.), Maxim and Weston's (Maxim-Weston Electric Company); and of the third kind are the machines manufactured by Siemens Brothers for continuous currents, and the machine of Edison.

There are many others, but I have selected the above as those at present in most general use.

The principle of all these machines may best be understood by an examination of the well-known machine so long used in drawing-rooms for giving magneto-electric shocks. Fig. 22 is a representation of it. The lines of force from the permanent steel magnet curve round in all directions from N. to S. (Fig. 23.) If the two iron cores mounted on radial arms and wound with copper wire coils be spun round on an axis, then as the iron cores come near the poles they draw to them the lines of force and make these lines more intense. The lines of force thus cluster into one iron core passing through the centre of the coil wound upon it, and throng out of the other iron core into the pole S.

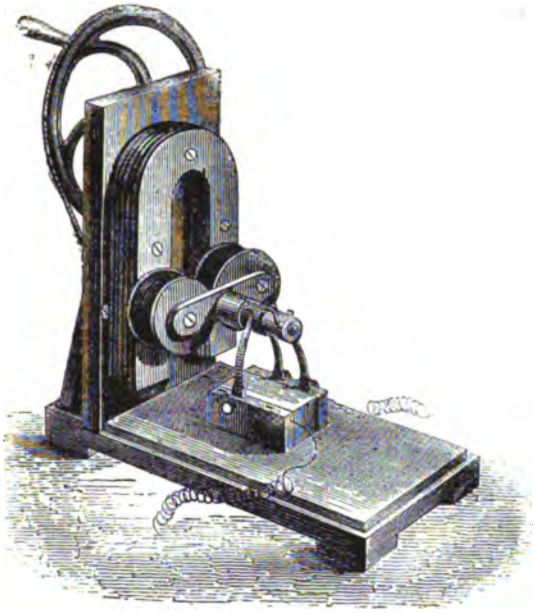


Fig. 22.

These cores are called armatures. As they move, the coils of wire on them are repeatedly cutting lines of force. Thus, in Fig. 23, the lines of force cluster into the pole armature A, and as

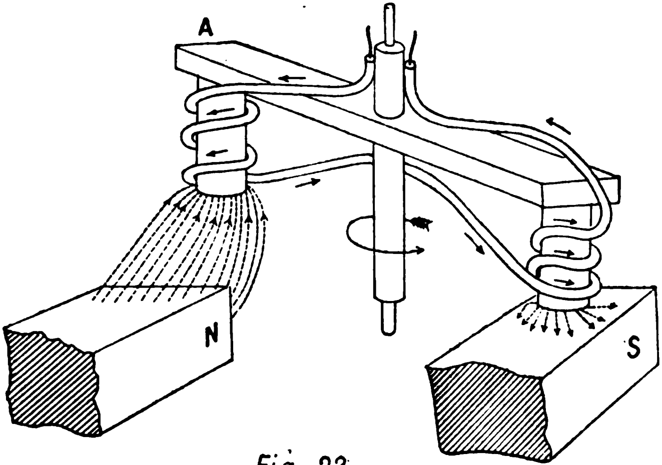
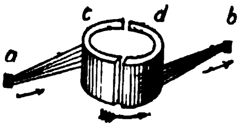


Fig. 23,

A moves in the direction of the arrow, the lines of force passing through it increase. Hence, to find the direction of the current, we need but suppose a watch placed in the centre of the coil A, Page 188.

with its face towards N., so that the lines enter the face and come out at the back, in order to know that as the number of lines cut is increasing, the current runs in the reverse direction to the hands of a watch whose face is towards it; that is, as shown by the featherless arrow. When the pole A comes opposite N., the direction of the current will, of course, be changed. As it goes round and gets midway between N. and S., the lines of force decrease till it begins to move towards S., when the lines of force will now enter it by the top instead of the bottom, raining down upon it from above, but at the same time their number will now be increasing, so the current will not change till we get opposite S., when it will again reverse. In fact, as has been said, pole armatures usually reverse current on passing the
Page 187. poles of the magnetic field. An alternating current is thus obtained, changing many times in a second. But so rapid is electricity, that if applied to lighting, though the current changed many hundred times in a second, or, indeed, as fast as human skill could make it, each current would go to the lamp, act on the incandescent fibre, make it hot, come back, and then give place to a reversed current, which would do the same so quickly that the effect would be equivalent to the effect of a continuous one. A good alternating current ought to reverse at least ten
Page 125. times in a second. With a slower rate than this the lamps appear to wink. Fig. 22 represents an alternating current machine. The electricity passing through the coils may be collected, for which purpose an apparatus, known as a collector, is necessary. For the wire from the coils cannot be carried continuously to the lamp, or else it would be twisted up by the motion. A sliding or rubbing contact must thus be made between the conducting terminals of the machine, and brass boxes fixed on the axle of the armature to convey away the currents from the coils as soon as they are formed. See Fig. 24, where C and D are brass semi-cylindrical bosses, and A and B are collecting brushes. Sometimes an apparatus known as a commutator is used. The object of this is to commute or change the currents by reversing the wires through which they are sent. Thus, when a current is passing through the pole-coils in one direction, the

Fig. 24.



current is taken away from the machine through the conducting wires, but when the current in the pole-coils is reversed, as the pole passes the north and south points of the field magnets, exactly at that instant the conducting wires are also reversed. So that the current is sent through them in the same direction as before. Such a commutator is shown in Fig. 25. It consists of

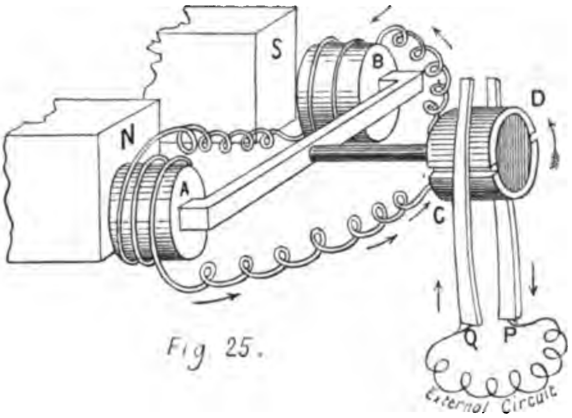


Fig 25.

two curved pieces of brass or bosses, C D, mounted on a small drum, or "hub," of non-conducting ebonite. C is connected with the coil round A and D with that round B. Two tongues of metal, P and Q, press by their own elasticity against the commutators C and D. When the pole-piece A is receding from N., the current goes out of A through C into P, round the external circuit, then to Q, then into D, then into B, and so back to A. At the instant A and B come opposite N. and S. the current is reversed, and now rushes out of B into the commutator D, and if D were in connexion with the tongue Q (as before) the current would be reversed. But the commutators are so placed that the instant A and B come opposite the poles N. and S., and the current is reversed, the commutators opposite P and Q are also reversed. D now comes in contact with P, and the current runs out of B, into D, down P, back through the external circuit to Q, into C, thence to A, back to B. Thus, though the current in the coils alternates, the current from P to Q is always in one direction. The action of the commutator is apt to make the current rather jerky, or intermittent. And this is the reason why instead of two commutators, great numbers are used on most practical machines. The machine just described is the common type of a dynamo. Instead of two pole-pieces, we have a great number, and the armatures are rotated by steam.

The electromotive force of all dynamos depend on—

(1.) The strength of the magnetic field, that is, the intensity of the permanent magnets.

(2.) The speed of rotation; the faster you go the more E.M.F. you get.

(3.) The number of coils of wire on the poles, for each turn of wire produces a proportionate effect of its own.

It might thus be thought advantageous to wind in all cases the armature with an enormous number of coils. This would be the case were it not for Ohm's law. For by that law the current depends not on the electromotive force alone, but on the electromotive force divided by the resistance. Hence, if the number of coils is very great, though the electromotive force becomes enormous, yet inasmuch as the wire has to be made thinner and longer, the resistance of the coils is increased. For example, if the wire were made half the sectional area there would be room for nearly twice as great a length on the core. This would double the electromotive force, but unhappily it would make the internal resistance four times as great, for the wire would be half as big in sectional area, and also double as long. For it must be remembered that the total resistance through which the current will have to be driven, is not merely the resistance of the external circuit, but includes also that of the dynamo.

To take an actual instance. Suppose that with a pole machine wound with 200 turns of wire, at a given speed of rotation, the electromotive force equals 50 volts, and that the internal resistance of the machine were one ohm, and that the resistance of the external circuit were .5 ohms. Then the current would be

$$\frac{50 \text{ volts}}{1 \text{ ohm} + .5 \text{ ohms}} = 33.3 \text{ ampères.}$$

If we now make the wire of the armature half the area in section, and twice as long, the internal resistance will become four ohms; the electromotive force, however, will (at the same speed) be doubled (since the wire being twice as long will make twice as many turns as before). The current will now be

$$\frac{100 \text{ volts}}{4 \text{ ohms} + .5 \text{ ohms}} = 22.2 \text{ ampères,}$$

Or only two-thirds of what the previous arrangement gave us. This shows that great knowledge and care are requisite in winding machines, to choose the proper size of wire for the purpose intended. With an external resistance of ·5 ohms, you would lose by making the wire smaller. But suppose the external resistance had been, say fifteen ohms, or that of a small incandescent lamp. Then as before, in the first case, we should have obtained current

$$=\frac{50 \text{ volts}}{1 \text{ ohm}+15 \text{ ohms}}=3.1 \text{ ampères};$$

While in the second case we should have got

$$\frac{100 \text{ volts}}{4 \text{ ohms}+15 \text{ ohms}}=5.25 \text{ ampères}.$$

So that for small external resistances you lose by having longer and thinner wire, but when you have large external resistances you must wind your wires rather thinner. Or, to put the matter in another way, long and thin wires on the armatures tend to give a high electromotive force with a large internal resistance. Short and thick wires tend to give low electromotive forces with small internal resistance. As a general rule high electromotive force is used for arc lighting, and low electromotive force for incandescent lighting. I call electromotive force high when it exceeds 200 volts. Over this, as has been said, it begins to be inconvenient to touch the wires, and at 800 volts would be probably fatal. The resistance of arc lamps is low. A large arc lamp has a resistance of only four or five ohms, whereas a twenty-candle incandescent lamp, when hot, has a resistance of from thirty to forty ohms.

In dealing with dynamos the nature of electromotive force must be remembered. It is a driving force tending to force electricity from one part of the circuit to another. Hence in strict accuracy we ought to speak of the electromotive force *between* two *points* in the circuit; just as in speaking of water we deal with the difference of pressure between two given points, such as the fountain head and the tap. The electromotive force of a dynamo ought to be measured as at the two terminals of the machine, and thus be the driving force through the external circuit. Suppose a current led from one terminal of a dynamo through two incandescent lamps in series, and then back to the dynamo, and suppose each lamp were a twenty-candle Swan lamp of No. C. pattern, which has a resistance of 39½ ohms when hot. Each lamp requires an electromotive force of fifty volts to drive sufficient current through it to light it. To light these lamps we should want an electromotive force of 100 volts at the terminals of the machine, giving a current through the

Page 244.

lamps of $\frac{100}{2 \times 39\frac{1}{2}} = 1.27$ ampères. This 100 volts represents the electromotive force between the terminals of the machine. But if we took the electromotive force between one terminal, and a point midway between the lamps, then the E.M.F. would only be some fifty volts.

To compute the power of a dynamo, we should proceed as follows:—First find the actual working horse-power of the driving steam-engine. The nominal horse-power of the engine is no use. Small engines are often worked at double their nominal power. The only safe plan is to insist on having a diagram taken by means of a Richards' steam-indicator. You then get the true work being done in the cylinder of the steam-engine. Next the resistance of the system must be tested. To do this the resistances of all the wires must be compared with standard or known wires, by causing currents to shunt through them and through the wires to be tested; then by observing how the current distributes itself, and knowing that it divides inversely proportionally to the resistances, the resistances of the wires can be calculated. Or again, if we know their size and length, we could compute their resistances by comparing them with the known resistances of certain sizes of copper wire. But it must be remembered that very slight adulteration is very detrimental indeed to copper wire, and easily lowers its conductivity. Hence care must be taken in calculating resistances from a knowledge of the size and length, to inquire as to the goodness of the copper. The resistances of the various parts of the circuit being known, they are then classed under three heads.

(*a*.) The resistance of the wires of the machine through which the current passes.
(*b*.) The resistance of the conductors.
(*c*.) The resistance of the lamps.

The electromotive force must next be ascertained. I do not propose here to deal with the way in which this is done, as it is rather complicated, but if the current be passed through a number of twenty-candle Swan incandescent lamps of pattern A *in series*, and light them up to their proper amount of twenty candles, then one may be pretty sure that the machine is working at about fifty volts for each lamp in the series.

Thus, if we have groups of such lamps in series of threes, then, no matter what the total number of lamps is, the electromotive force of the machine would have to be 150 volts. Or if we had any number of ten-candle lamps in groups, say of four lamps, arranged in series in each group, then, since the electromotive force required for each lamp is known to be about 27 volts, we should know that to light them to their proper extent, the machine would have to be working at 4 × 27 = 108 volts. Having thus got the electromotive force, and resistance of the total system, by adding up *a*, *b*, and *c*, we can obtain the current in ampères by the formula—

Page 177.

$$C = \frac{E}{(a+b+c)} = \frac{\text{Electromotive force of engine}}{\text{Total resistance of machine, conductors, and lamp}}$$

or conversely, if we knew the strength of the current in ampères, and the total resistance of the system, we could multiply them together to get the electromotive force, thus $E = C \times r$.

Page 244.

It must be remembered that when an incandescent lamp gets hot the resistance is very much reduced. Thus an incandescent Swan lamp of I. pattern, having a resistance of 88 ohms when cold (or equal to that of an ordinary electric main half an inch in diameter and about 400 miles long), has when hot a resistance of 55½ ohms, or only equivalent to 255 miles of the same wire. This example shows how small the loss of electricity ought to be, if mains are constructed of a proper size.

The making of magneto-electric machines had not advanced far when it was perceived that their efficiency could be much increased by using electro-magnets, instead of permanent magnets, to excite the field. For electro-magnets are much more powerful than permanent magnets. A step further would be reached by using the current itself to generate the magnetism in these field magnets. With this arrangement, when the machine begins to work, the electromotive force will be exceedingly feeble, the only magnetism available to furnish the magnetic field being the small residual magnetism generally found in iron, however soft. But as the current commences to flow the field magnets become stronger: this re-acts by causing the electromotive force to become greater: the current round the circuit is thus increased, which in its turn re-acts on the electro-magnets, and so on, until the limit of magnetic capacity of the iron is reached. At this point the increase of current makes no appreciable difference in the magnetization of the field, and the working of the machine becomes uniform. When such a machine is commenced to be worked, it offers but little resistance to the driving force; but as the current is gradually developed, the resistance becomes greater and greater, the energy of the current increasing in like proportion.

If while a machine thus arranged (called a "series-wound dynamo") is working, fresh resistance is introduced into the external circuit, the current is thereby weakened. The effect of this is also to weaken the electro-magnets. Thus the more work the machine has to do, the less is the electromotive force available to do it; and, on the other hand, when the external resistance becomes very small, the current round the magnets is enormously increased, and a high electromotive force generated just when it is not wanted. To avoid these inconveniences, what is called the shunt winding is introduced. Instead of sending the whole current round the field magnets, only a portion is sent round them, such portion being shunted off from the main circuit. This does not seem an important difference at first sight, but its effects are very curious; for if any additional resistance is introduced into the external circuit, the shunt wound round the magnets will now take a greater proportion of the current than before, and thus the field magnets will increase in strength. A machine so wound therefore rises to its work; but such a machine has a tendency to rise to its work too rapidly. A considerable increase of resistance in the external circuit will cause a disproportionate increase in the electromotive force. Hence, then, a series-wound dynamo is defective in one manner, while on the other hand the shunt-wound dynamo is defective in exactly the opposite respect. The electromotive force, or, as it is often termed, the "pressure," falls off with increased work in the one case, and increases too much with increased work in the other. To avoid these extremes a combination winding is employed, which causes these opposite effects to neutralise one another. The field magnets are wound with a coil from the main wire, and also with one from the shunt, and the total result is a steady uniformity of electromotive force, whatever be the resistance of the external circuit, the amount of the current varying as the resistance is varied. Alternating current machines cannot be self excited, for the alternating current they produce is incapable of creating a permanent magnetic field. They must therefore have their field magnets excited by separate continuous current machines. It is, however, necessary to remember that there is a limit to the capability of iron to become magnetic under the influence of a current. Up to this point the magnetic force will vary with the current, but beyond it additional current produces no corresponding effect. This

Page 192.

cause alone limits the intensity to which magnetic fields may be raised, and necessitates the use of larger dynamos to produce a given effect than would be necessary if the force of small ones could be indefinitely increased.

Sec. 2.—*Pole Armature Machines.*

The Lontin Machine.

Of all the pole armature machines, the simplest in theory is that of M. Lontin, now the property of the Maxim Weston Company. A side view of the machine is shown in Fig. 26.

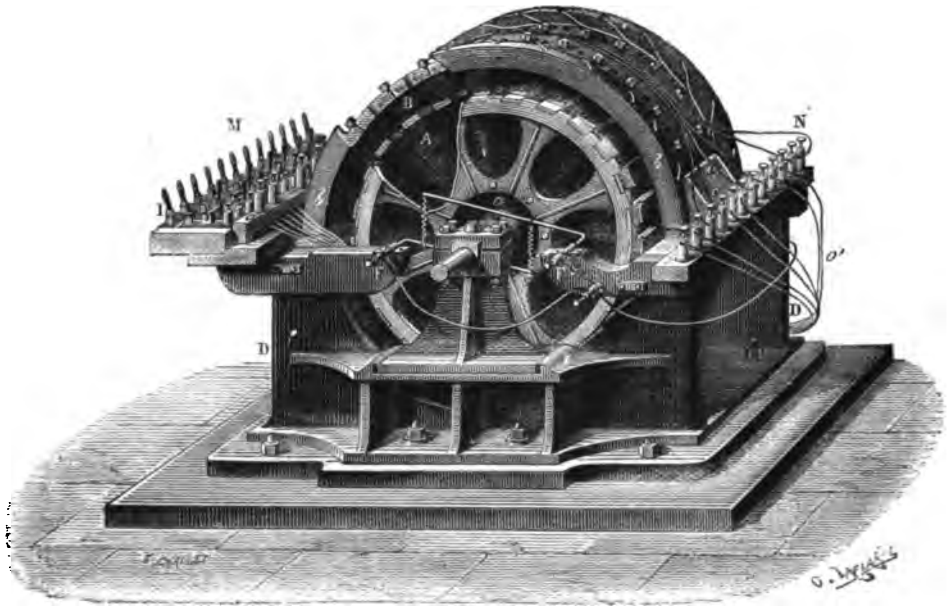


FIG. 26.

It consists of an amplification of the elementary electro-magnet machine already described. Four or more rows of pole-pieces are employed, being placed spirally round the drum, each row slightly in the rear of the preceding. The whole of the current produced in the armature is sent round the field magnets.

The current is collected in the following way:—The wire wound round each pole-piece is carried down to a segment of a brass commutator, and then back to and round the next pole-piece, then back to the next commutator, and so on. Brushes press against the commutators at A and B. As the pole-pieces travel from N. to S., currents are generated in the wires round

Fig. 27.

them in the backward direction shown by the small arrows, (Fig. 27) and are carried off by the brush at A. But directly the pole-pieces pass S. the current is reversed, and hence the current still flows from B towards A, on the under side of the armature as well as on the upper side. The result is, a continuous current between the brushes at A and B.

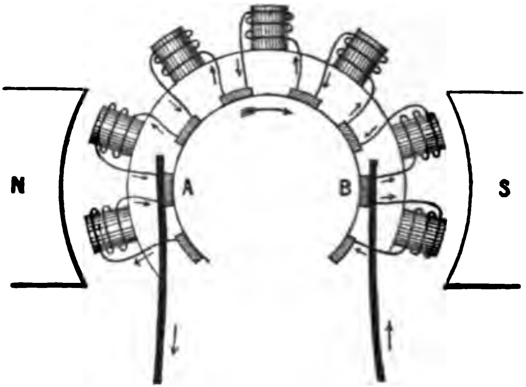


Fig 27. Diagram of pole armature machines in general.

There is also an alternating current machine, on much the same principles. This machine is not very efficient, and the noise it makes in action is intolerable. I believe no more are made at present.

The Gordon Dynamo.

This is the largest dynamo that has yet been made, with the exception of a machine on much the same principle, which has been constructed at Paris, by M. Gerard.

It is a pole armature machine, but with the peculiarity that (as in the alternating Gramme machine) the field magnets are caused to rotate while the coils in which the electricity is generated remain fixed. The use of collecting-brushes is thus avoided, but the current is alternating. The machine is shown in Fig. 28. It consists of a large central wheel composed of two boiler-plate cones, mounted on an axis, and carrying on the circumference thirty-two large electro-magnets, which are fed by means of a separate small dynamo, called an "exciter." This wheel being about 8¾ ft. in diameter, serves as a fly-wheel to the engine, and is caused to rotate at about 140 revolutions per minute; at this speed there is no fear of an

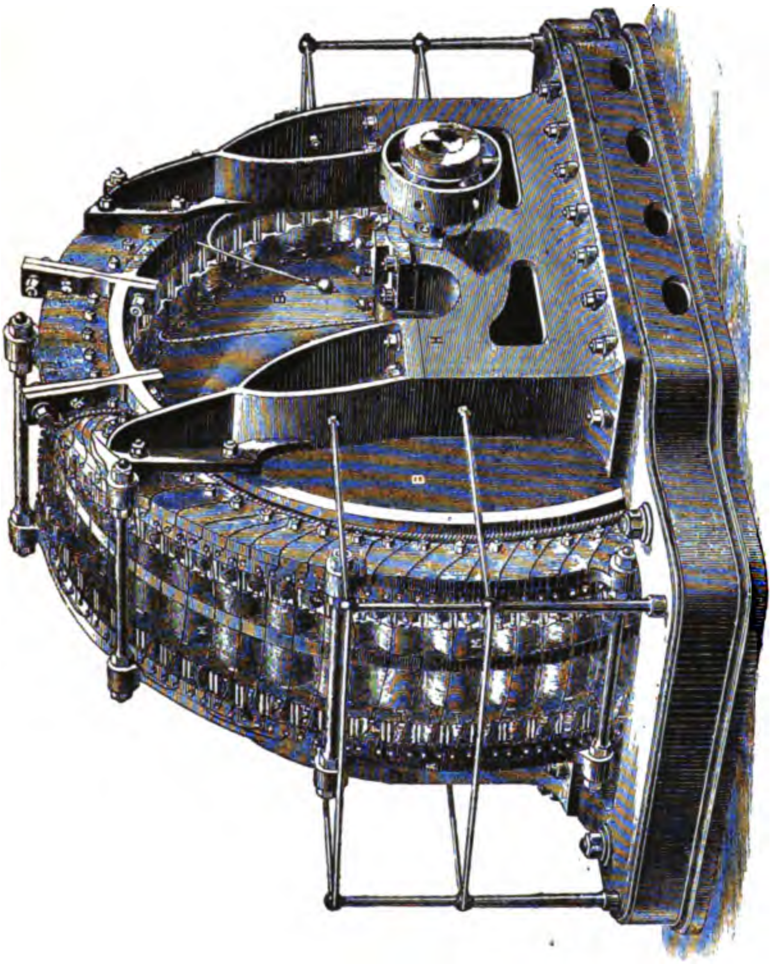


FIG. 28.—THE LARGE GORDON DYNAMO.

accident. The wheel thus rotating and carrying the field of force round with it, is enclosed by two "crowns" of sixty-four iron cores. These are placed upon two rims, one on each side of the revolving wheel. Each core is wound with about 130 ft. of No. 7 wire, and they are so arranged that they can be joined up in any way that is desirable. This is a great advantage. Moreover, induced currents cannot be formed in the iron frame carrying the cores, for it is only a rim just large enough to hold them. During the month of January, 1883, the machine was being run at the rate of 140 revolutions per minute, under a pressure of steam of fifty-four pounds to the inch, and at 170 horse-power, as shown by a Richards' indicator. The machine was built for a 500 horse-power engine and thus was not working very econonomically. The field magnets on the revolving wheel were excited by a small Crompton (Bürgin) machine, giving a current of about twenty-five ampères at an E.M.F. of about 100 volts, and with an expenditure of four or five horse-power. The total horse-power employed to drive the dynamo and exciter was thus 175 horse-power actual. This resulted in a current drawn off from the fixed crowns of coils sufficient to light 1400 20-candle Swan lamps. A photometer showed that the lamps near the engine had a power of about 22½ candles. But of course those further off would not be so bright. These lamps were arranged in series of twos in parallel arc. The resistances of the system were as follows:—

The machine - - - - -	.0075 ohms.
The conducting wires - - - -	.006 ,,
The lamps - - - - - -	.085 ,,
Total . .	.0985, say .1 ohm.

hence, the E.M.F. being = 103 volts; the current $= \frac{103}{.1} = 1030$ ampères. According to this estimate the energy of the current would $= E \times C = 103 \times 1030 = 106.090$ volt-ampères or about 600 volt-ampères per horse-power, while the lighting capacity could not have been less than about 175 candles per horse-power. The current is not dangerous and the terminals can be touched by the hands without inconvenience. It is to be hoped that an opportunity will soon be afforded for working one of these machines on a large scale with the 5000 lamps for which it was designed.

The machine is regulated, when working, by a man who watches a photometer, and turns the steam off and on until the proper degree of light is obtained. It is being generally recognized that for large machines of all kinds, human regulators are more efficient and even cheaper than automatic arrangements; and where large dynamos are employed it will probably always be found necessary to have a workman at a wheel, like a helmsman, with ammeters and photometers, by which to regulate the steam.

Sec 3.—Ring Armature Machines.

We now pass to armatures of the ring type. These were first regularly designed by Professor Pacinotti, of Bologna; and an account of them published by him in a magazine called "Il nuovo cimento" (the new experiment), vol. xix. There is a copy of this periodical in the British Museum (which copy was, however, acquired at a date considerably after its publication). A sketch of it is given in "Nature," vol. xii., p. 90.

The theory of the ring armature is as follows:—Let a ring of soft iron, which can rotate about an axis running perpendicular to its plane through its centre O, be placed between two magnets N. and S.

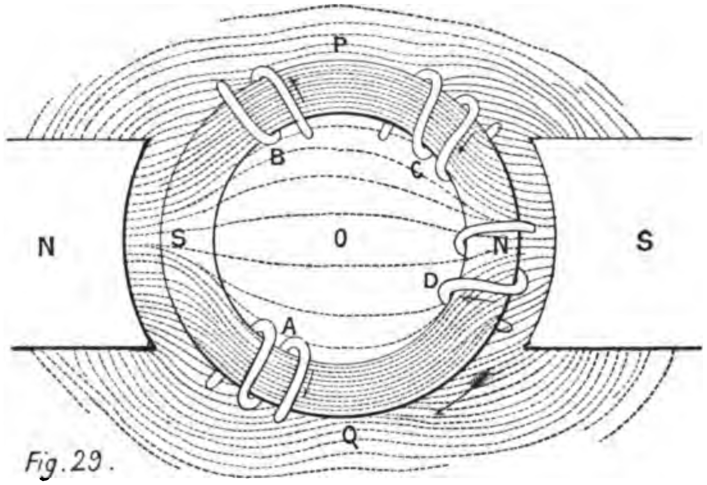


Fig. 29.

In consequence of the properties of the iron of the ring, the lines of force between the magnets will now be deflected, and will throng into the ring opposite N., traverse it on both sides, and come out opposite S. A few will go across the centre of the ring, but most of them will, if they can, pass through the iron. Now suppose a coil of wire to be slid round on the ring in the direction **Page 165.**

of the feathered arrow; then, when it is in the position A, the number of lines of force passing through it will tend to diminish, for its left hand or outer side will cut through more than its right. Hence a current will be generated in the direction of the hands of a watch whose face is turned towards N., or as shown by Page 186. the featherless arrow near the coil. Refer also to Fig. 16. Again, as the coil comes to B, the direction of the current will be the same, but on passing P the curent will be reversed, as shown at C and D. The current will thus run in one direction as the coil passes from Q to P, but in the opposite as the coil passes from P to Q. Now suppose we had a great number of these coils, covered with insulating cotton or silk, and wound round fast on to the ring with projecting ends, scraped bare and soldered together at intervals *p*, *q*, *r*, as shown in Fig. 30; then, if the ring itself were to revolve, carrying the coils with it, the same effect would be produced. For the ring being of soft iron, the lines of force do not sensibly alter in position, but the molecules of iron pass on, each as it comes taking up the line of force formerly taken by its predecessor. As in a river rushing over a rock, the particles of water change, but the wave left over the rock, which salmon fishers know so well, is left a permanent elevation, though the water of which it is composed is constantly changing.

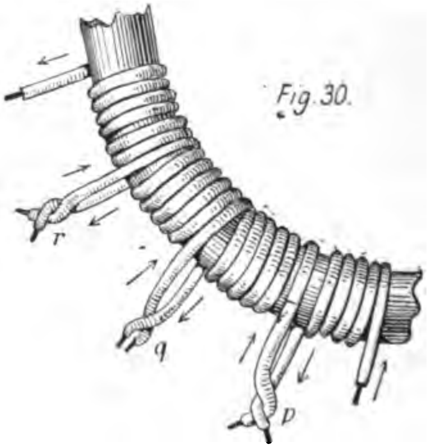


Fig. 30.

The result will be that a continuous current will run round and round each coil into each junction at *p*, *q*, *r*, and on to the next coil; and the directions of the currents will run in the coils in one direction as they proceed from P to Q (Fig. 29), and in the reverse as the coils proceed from Q to P.

But since all the coils are united, the current generated in one would run through all the others, so that the currents generated at any time in coils in the half of the ring from P to Q would neutralize those in the coils between Q and P, and thus no effect be produced. This is prevented by the use of collectors or brushes placed at P and Q. The current rushing from P to Q on one side, meets the reversed current coming from P to Q on the other side. The two currents then unite, like confluent streams of water, into one current, which finds an exit through the collector placed at Q, and thence goes through one terminal of the machine into the external circuit, having traversed which it returns to the other terminal, and re-enters the ring through the collector at P. The theoretic position for the brushes is, therefore, midway between N. and S., that is, at the points P and Q. But in practice it is found needful to place the brushes at points between P and S. and Q and N. respectively; or, as it is called, to give them a "lead," a certain distance in the direction of the motion in front of the theoretic position. The reason of this I now propose to explain. It will be remembered that a current flowing through a wire coiled round a piece of iron tends to make that iron magnetic. As soon, therefore, as the motion of the ring has generated a current in the wire round the ring, the current makes the ring magnetic, apart from the induced action of the magnets N. and S. Under this influence Q tends to become a north pole, as may

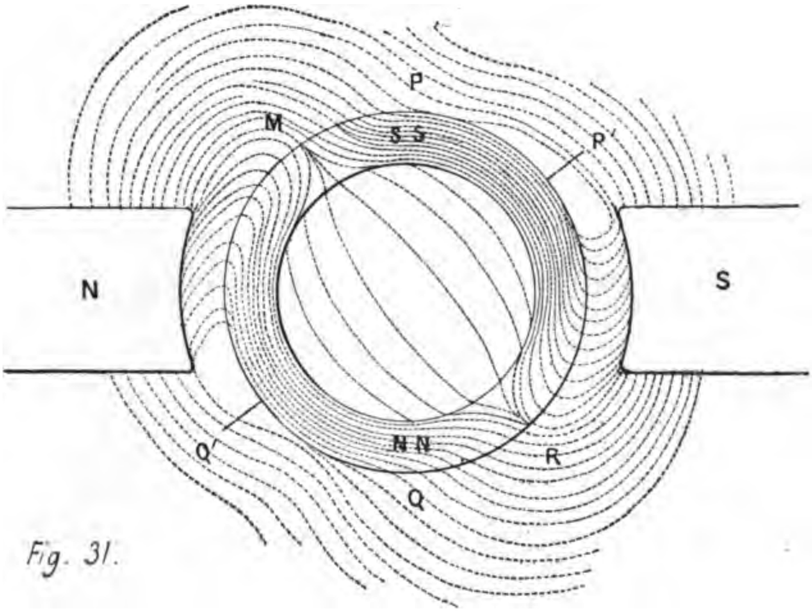


Fig. 31.

easily be seen by examining the direction of the current (Fig 29),* and P a south pole. So that the ring is then like two curved semicircular magnets with their north poles joined at Q and their south poles at P. (Fig. 31.) In consequence of this, the lines of force proceeding from N. are repelled from the part of the ring between Q and N., and tend to throng into the part between N. and P, and out at a point between S. and Q, and thus the points of greatest intensity, instead of being opposite N. and S., as in Fig. 29, are now opposite M and R. Hence the ring, instead of having its induced N. and S. ends opposite N. and S., now has them shifted to M and R. This involves a shifting of the neutral points, too. For instead of being at P and Q as when the ring was at rest, Fig. 29, these neutral points, by the combined action of the induction of the magnets N. and S., and the action of the coils on the ring, now take up the positions P′ and Q′, which are determined by the relative intensity of the magnetic field to the strength of the current round the ring, and by the size of the ring itself. And the faster the ring moves the greater the electromotive force, hence (the resistance being the same) the greater the current in the coils, the greater the current-induced magnetism of the ring, and the greater the shifting effect referred to. There are further refinements which might be gone into, which, however, would be out of place here, for if very fully treated

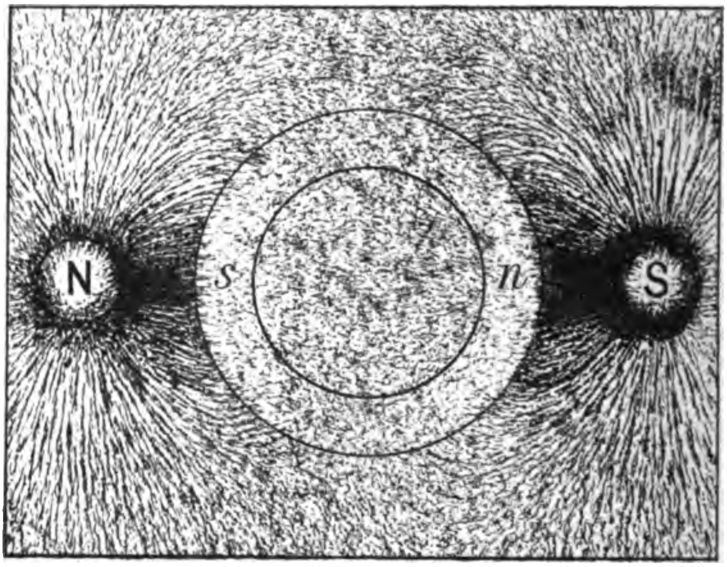


Fig. 32.

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* Compare the magnets in Fig. 8, p. 179, with the coils, Fig. 29.

the action of a Gramme ring is rather complicated. Meantime it may be enough to say that if the poles of two magnets, N. and S., are placed in the same horizontal plane with the soft iron ring at rest between them, the lines of force will be attracted towards the ring (see Fig. 32), which has been experimently made by placing a ring of soft iron between magnet poles N. and S., and then scattering iron filings over a piece of glass covered with

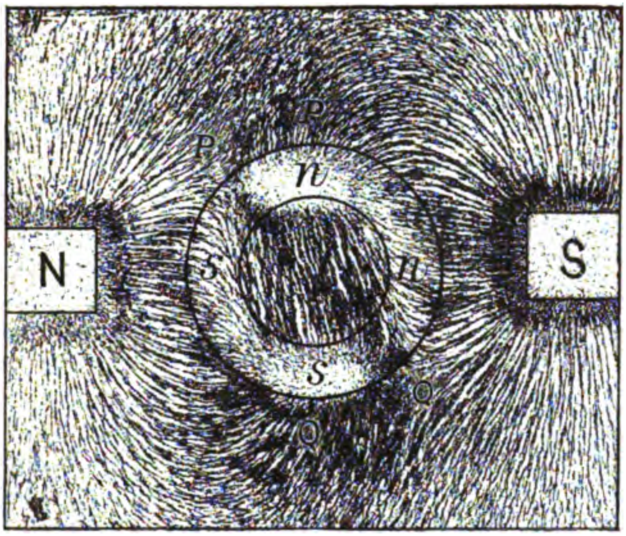

FIG. 33.

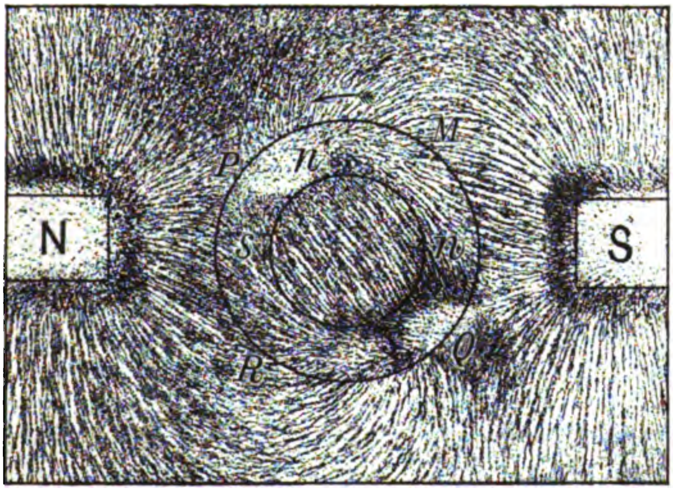

FIG. 34.

gelatine, which is steamed and warmed so as to seize and retain the particles of iron, and thus show the lines of force. We can now imitate a Gramme ring in motion, by winding the iron ring with wire, and sending a current in at P, so as to go along both sides of the ring and come out at Q. Under this treatment the shifting motion above referred to is at once evident (Fig. 33) and the neutral points appear at P and Q′, to which point the commutators ought to be shifted. This, however, when done, would modify the figure still further, and we should finally have the Figure 34 with rotation in the direction of the arrow. The commutators would be shifted round to P and Q, and the resulting *n* of the ring would take up a position (at M) between P and S, while the resulting S. would be (at R) between Q and N. In this case I used a very strong current round the ring, and, therefore, N. and S. are very far shifted; as a rule they would be much nearer S. and N. respectively. In small model dynamos, these points take up very extraordinary positions in practice. In large dynamos, as a rule, the commutators are inclined at about 45 deg. to the line between the magnets. The chief function, therefore, that iron plays in the armature is to attract and concentrate the lines of force. An armature could be constructed without any iron at all. It would still require a forward lead to the armatures. There are also certain phenomena attendant on the action of dynamos, and depending on what is known as self-induction. But I omit mention of these for simplicity.

The Gramme Continuous Current Machine.

In practice the form of the Gramme is not unlike that of the Pacinotti machine, and is represented in Fig. 35, in which the ring, the magnets, and brushes are very clearly shown. The pulley on the left is caused to rotate by means of a strap from an engine at about 1000 revolutions a minute. The nature of the action of the ring has been already explained, and is further illustrated by the diagram, Fig. 36, which shows the circulation of the current through the armature and field-magnets. The objection to all ring armatures will always be that they are somewhat expensive to construct. The ring is made of a coil of soft iron wire, well united with pitch into a solid mass (Figs. 37 and 38). This is to prevent induced currents being generated across the ring itself. For a mass of iron, when made to rotate cutting lines of force, will also give rise to currents as well as a wire, and then much valuable force may be lost in the useless production of currents in the iron armature when they are not wanted. All metal in armatures is therefore an evil. Brass or copper, except for the wires, is always positively injurious. Iron is hurtful in so far as it tends to have currents set up in it, but it cannot well be dispensed with because it is so useful in collecting the lines of magnetic force, and thus intensifying the magnetic field. The collectors or commutators of a Gramme machine are made of angular bars of copper, insulated from one another and placed round the circumference of a wooden cylinder. This is shown in Fig. 37, which is a section of a Gramme ring, showing the ring, the coils, the conducting bar from the junction of each contiguous pair of coils, the ends of which conducting bars

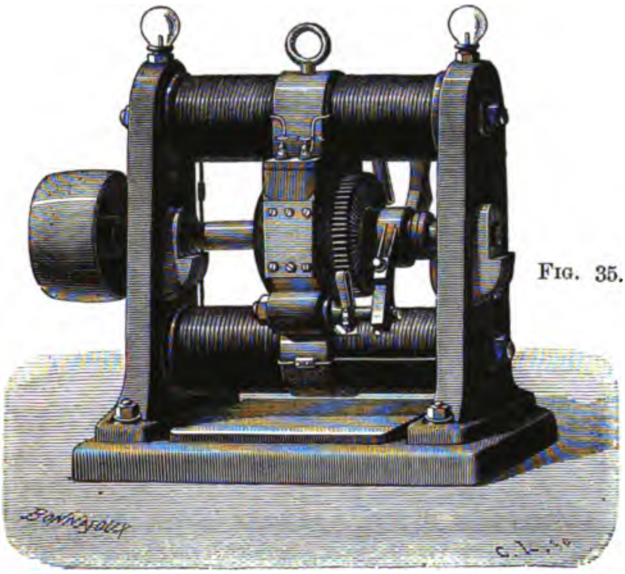

FIG. 35.

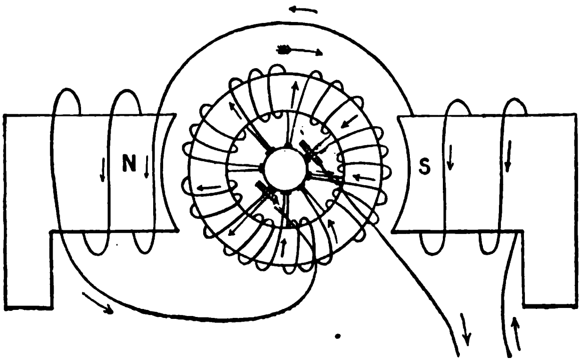

FIG. 36.

come successively into contact with the collecting brushes as the ring rotates. M. Gramme was originally a Paris workman, and has never claimed the position of a savant. His work has been entirely of a practical nature, and has resulted in the acquisition of a large fortune. His English patent is a singularly meagre document, not even containing drawings; the patents in other countries are more ample.

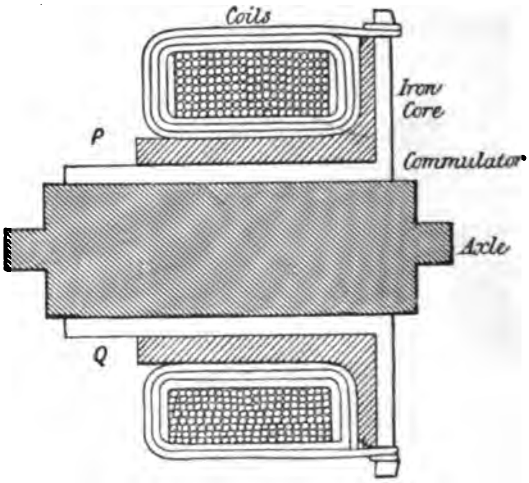

Fig 37 Section of a Gramme ring

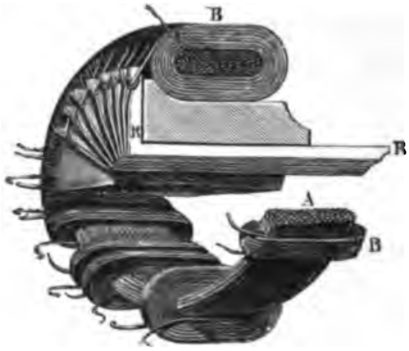

FIG. 38.

The Gramme Alternating Current Machine.

Besides the direct current machine above described, Gramme has also invented an alternating-current dynamo. The plan of construction of this machine is, instead of causing the ring to revolve within fixed field magnets, to make the field magnets revolve within a fixed ring. The current is drawn off from the ring as before, but no commutators are used, as the ring is not in motion. The current is simply carried direct by wires from the wire of the ring. The current which is to magnetise the internal revolving field-magnets is conveyed to them by two switches or tongues pressing against a cam of copper revolving on the axis. The magnetism of the pole-pieces of the revolving field magnets (which are eight in number) acts on the iron in the ring and alternately makes each part of it north and south. As a consequence alternate currents are sent through the coils of the ring. As the alternating current cannot be utilised to excite the field magnets, they must be separately excited by means of an ordinary continuous Gramme ring mounted on the same axis with the alternating dynamo. For convenience the coils on the outer ring of the alternating machine are wound into four circuits, interspersed among one another into thirty-two sections. By this means four distinct currents are got from the machine, which can be used either separately or together.

Fig. 39 represents the finished machine. The connectors for the four circuits will be observed above. On the right is the steel pulley for the engine strap. In the centre are the coils of the fixed ring, while through the opening on the left can be seen a part of the exciting machine, consisting of a ring revolving in the centre of fixed field magnets. The current from this ring is conveyed to the revolving field magnets within the fixed ring shown on the right, which conceals them from view.

One of these machines is at present working in the Aquarium (London). It revolves at 700 revolutions per minute, and the current therefore alternates 5600 times in a minute. Each of its four currents works five Jablochkoff lights in series. The resistance of each light is about four ohms, and the electromotive force required to light it is about forty-two volts. The total internal resistance of the Gramme dynamo (which in this case is wound with rather fine wire) is about ten ohms. We thus find that the current in each circuit $= \frac{E}{r} = \frac{5 \times 42}{2\frac{1}{2} + 5 \times 4 + \frac{1}{2}} = 9.1$ ampères; (allowing two and a half ohms for the internal resistance of each circuit of the machine and half an ohm for the external, and four for each of the lamps). Hence current equals 9.1 ampères at 210 volts. This gives a total of 7684 volt-ampères to the whole machine. Including loss on exciters, shafting driving belts, &c., the machine is supposed to be taking seventeen horse-power (French measure), or about 16¾ horse-power (English). We thus get a work out of it of about 460 volt-ampères to the horse-power. This seems only fairly efficient, but much better results have been obtained from other machines of the same make. It must be remembered that in all these calculations there is great liability to error. The lamps burn unevenly, and the resistance varies enormously; the amount of horse-power taken is at best only a guess; and I give these examples rather to show the modes of computation, than as expressing the value of any particular dynamo. The twenty lamps above referred to were of the nominal value of 400 candles each, or a total of 8000 candles produced by 16¾ horse-power.

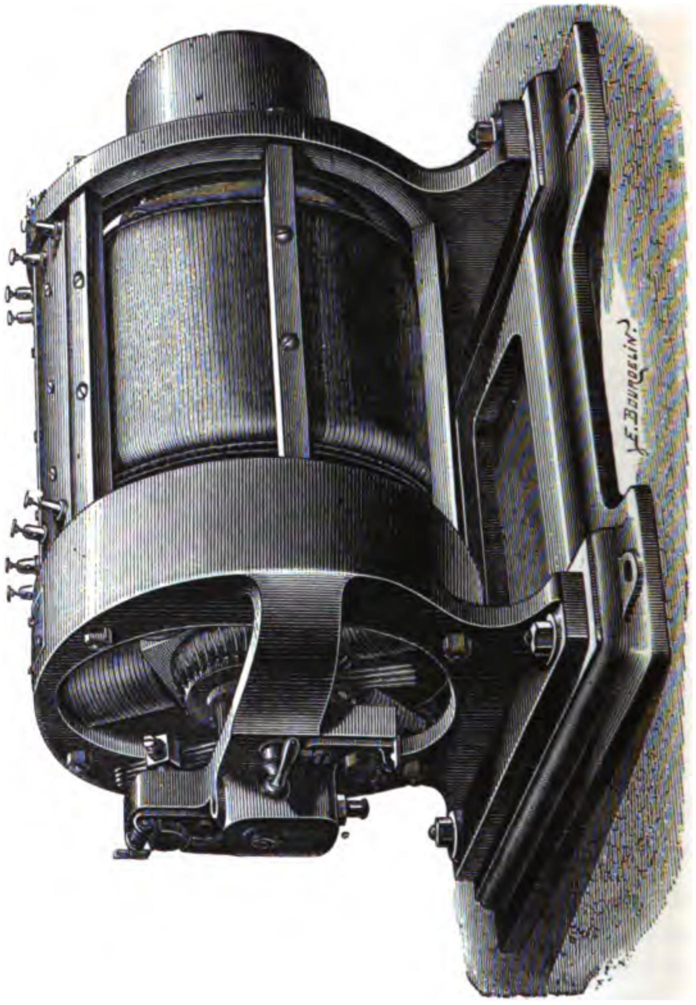

FIG. 39.

The Gramme Patents are owned in England by the British Electric Light Company. In America they are the property of the Gramme Electrical Company. The company has its offices in New York, and the following companies are shareholders. The American, the Brush, the Edison, the Fuller, the Jablochkoff, the United States, and the Weston. The president of the company is Colonel Hazard. The company owns or controls about 400 patents of Weston, Brush, Farmer, Jablochkoff, Edison, Maxim, and others. Thus united, these companies would present a strong front to any one who should attempt to oppose their common interests or infringe their patents.

The Brush Machine.

The next important machine of the Gramme type is the Brush machine. This machine is in reality almost identical with that of Pacinotti. The chief point of difference between the machines of Pacinotti and Gramme is, that the Pacinotti ring contains projections, or teeth, which are left bare, while the wire is wound in the spaces between them. The use of these is twofold. In the

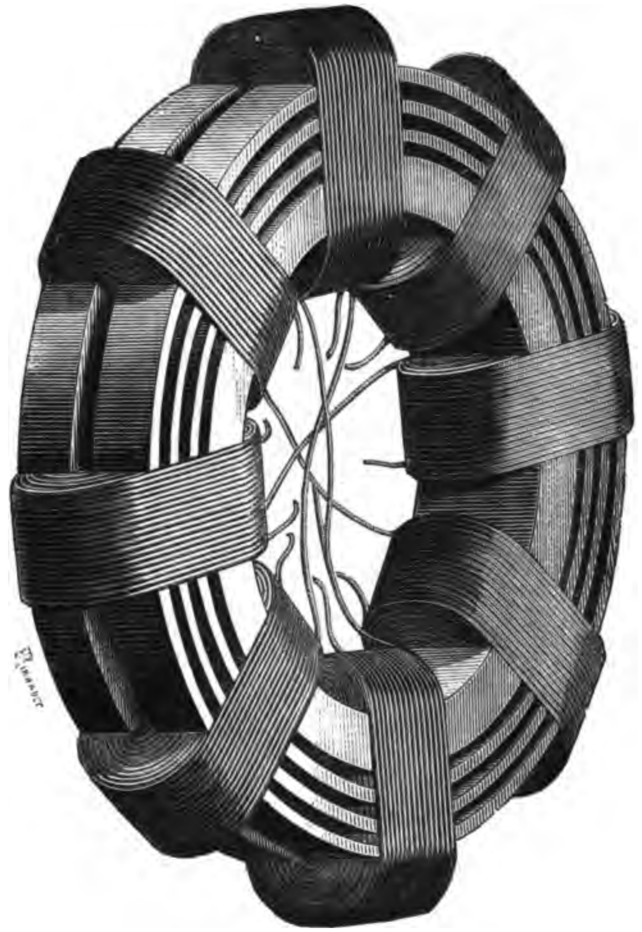

Fig. 40.

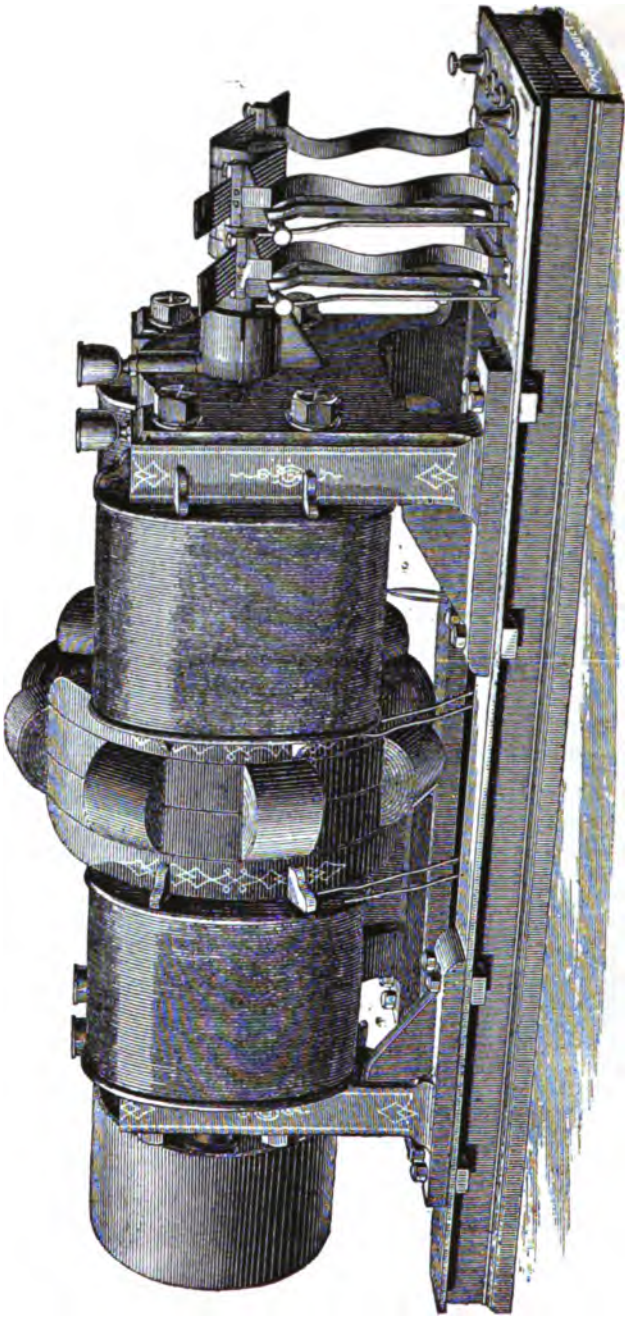

FIG. 41.

first place, the bare teeth as they rotate come into close proximity to the field magnets, and thus draw into the ring a great number of lines of force; in the next place, the teeth of the ring form spaces between the coils, and cool the wires, which are apt to become heated by the current. Mr. Brush further improves Pacinotti's teeth by cutting deep grooves in them, which not only further aid in the cooling, but also prevent the formation of injurious local currents in the iron, and lighten the weight of the revolving armature. The machine, like the Gramme, gives a continuous current. A Brush armature is shown in Fig. 40, and a picture of the complete machine in Fig. 41.

These machines are usually wound with rather fine wire; their internal resistance is therefore great, and the electromotive force high. The field magnets, instead of being presented to the circumference of the ring, are presented to the sides of it. This machine is a very good and efficient one. It is said not to be suitable for incandescent lighting; but I cannot help believing that this view is erroneous. It is true that with a high electromotive force of (say) 800 volts, the incandescent lamps would have to be placed in series of twelve or sixteen, and this is objectionable, for reasons that will be afterwards pointed out; but I doubt whether the experiment of incandescent lighting has been properly carried out, or whether the lamps tried were really good ones. For it is impossible to believe that a good machine, with properly adapted winding to the magnets and armatures, cannot be made to light any sort of lamps. At present, however, the Brush companies seem inclined to rely rather on a new machine which has been designed for them, somewhat on the Gramme model, than on the Brush, for incandescent lighting. The efficiency of the Brush seems to be about 75 per cent of the work done in the cylinder of the steam-engine. Of course its true efficiency is much higher, for a great deal of power is lost by the friction of the belting. One practical objection to the machine is its very high electromotive force; for a single shock at 800 volts, if received into the body, would probably be fatal.

There is, however, one very great advantage in point of economy in machines with a high electromotive force, viz., that when the electromotive force is high, then, in order to obtain the requisite energy, the current may be small, and therefore the conducting wires may be made of much smaller dimensions than when the current is large and the electromotive force is low. The cost of copper is so large that this consideration is one of great importance in practice.

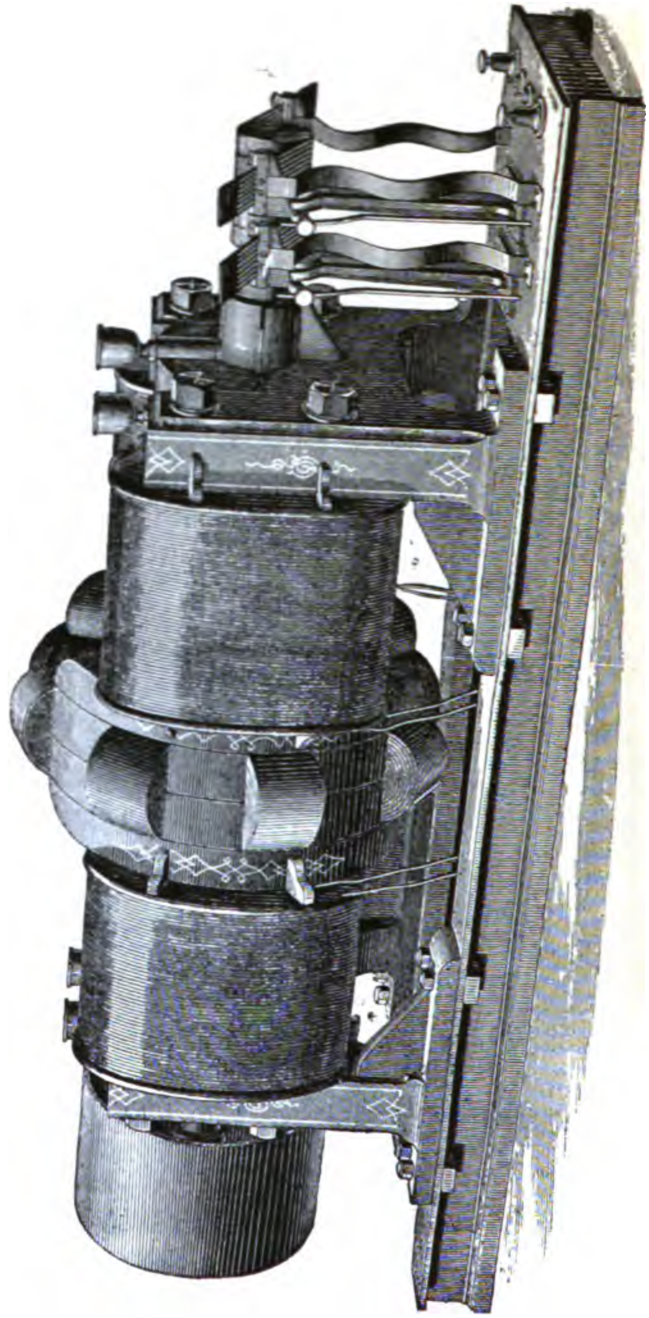

Fig. 41.

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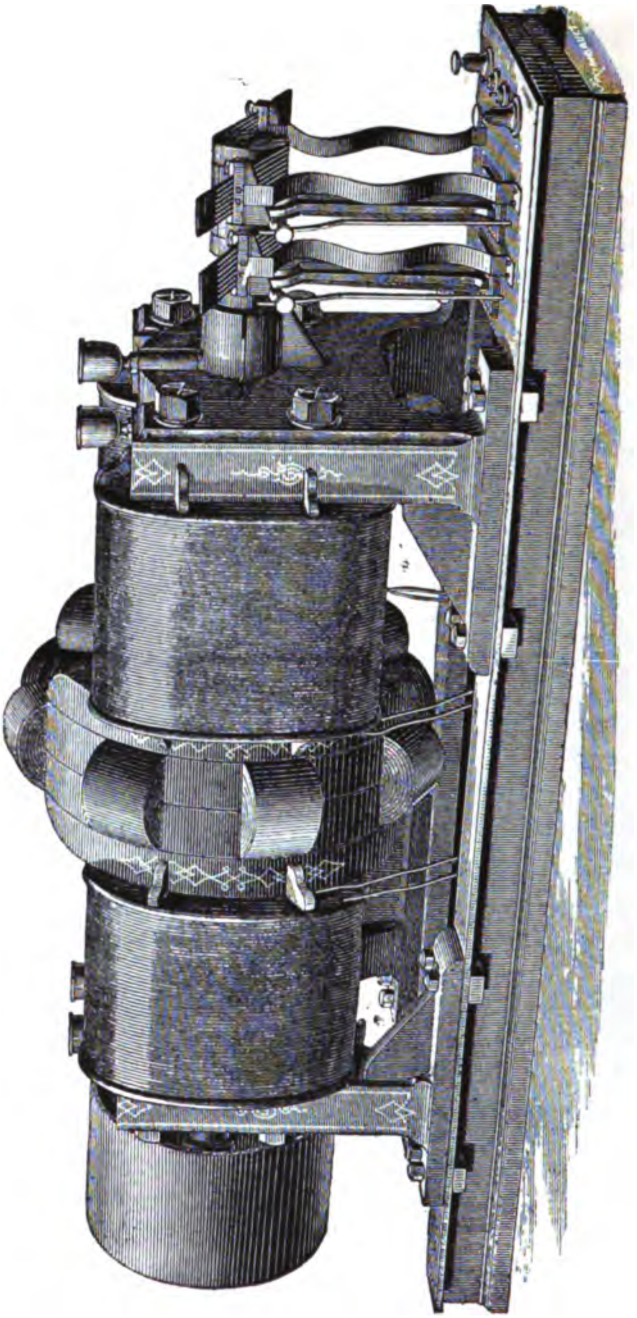

FIG. 41.

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Two Brush machines are at present in use in the South Kensington Museum. They are driven by an engine of fourteen horse-power (nominal), but worked to about thirty-eight horse-power. They light thirty-two arc lights, besides some incandescent ones. The light is very valuable, in that it does no injury to the frescoes and paintings and other works of art, but it flickers in an unpleasant manner. The students can study in colour as well as by daylight, which the electric light strongly resembles. It is estimated that for one arc light now used, 270 cubic feet of gas per hour were formerly employed. Each arc light is calculated to cost less than twopence-halfpenny per hour for fuel, labour, etc., whereas the gas cost about ninepence. The above cost of electricity does not include interest on capital outlay, which, however, is estimated at three times the annual saving of gas. In three years, therefore, the machines will have paid for themselves. The repairs needed in the last year have only been one or two fresh brushes and a piece of commutator copper, and not amounting to one or two pounds. This is attributed to the excellent mechanical construction of the Brush machine, and the accurate manufacture and fitting of the various parts. The efficiency appears to be about 500 volt-ampères per horse-power, of which, however, the dynamo, owing to its high internal resistance (about 10 ohms), absorbs a good portion.

In comparing the relative efficiency of gas and electricity above cited at the Kensington Museum, it must be remembered that the gas was previously used in a most inefficient and wasteful manner, as regards its light-giving powers. It was distributed in long pipes with numerous jets round the angles of the cornices of the rooms. The present light is, therefore, probably not as great as the gas formerly gave, but is more efficiently arranged.

For all public buildings, especially art-schools, there is no doubt that the electric arc light will prove a great success. For concerts, especially when organs are used, it is also very valuable; for inequality of temperature in a room where gas is used will alter the pitch of organ pipes so as to throw some of them half a tone out of tune in the course of the evening, putting them thus out of relation with the pipes not so affected.

The Bürgin-Crompton Machine.

This machine is the invention of M. Bürgin, of Bâle, but it has received such improvements at the hands of Mr. Crompton, notably as regards the combination shunt-winding of the field magnets, to which I shall presently allude, that it is usually called the Crompton machine. It is made by Messrs. R. E. Crompton and Co., whose works are at Chelmsford.

The machine is of the Gramme type, but differs in this, that each ring of iron wire, instead of being circular, is hexagonal (Fig. 42). Upon each of the hexagonal sides a bundle of copper wire R is wound, thickly at the middle and thinly at the ends. The wheel thus acquires a circular form, and the iron exposed at the angles is brought close to the magnets, and thus possesses many of the advantages of a Pacinotti ring. By this means also the wires are kept cool. The general disposition of the field magnets is the Gramme arrangement, and the commutators are much the same as in a Gramme machine. But on each spindle eight Gramme rings are arranged, thus increasing the electromotive force. These rings are placed spirally, each a little twisted upon the other, so as to make the current as continuous as possible (Fig. 42). This machine gives a current apparently of about 550 to 600 volt-ampères per horse-power of work done in the engine cylinder, a very favourable result, indicating an efficiency of over eighty per cent. The internal resistance is about three ohms, or about one-third of the Brush machine. This of course wastes a small portion of the current.

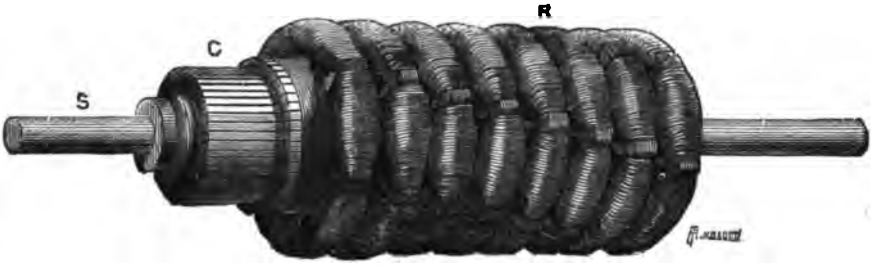

FIG. 42.

Mr. Crompton has made the most successful adaptation of the combination winding before described. The field magnets are wound with thick wire on the inside and thin wire on the outside. This results in an electromotive force so steady, that any number of lamps may be turned on or off without sensibly affecting the brightness of those that remain.

The Royal Courts of Justice are now being lit on this system. The power is supplied from a Marshall's semi-portable engine of 20 horse-power (nominal), which can be worked up to 60 horse-power. The consumption of coal is stated to be about 70 lb. per hour; and the engine is at present worked from 20 to 30 horse-power, as far as is known, for no indications had been taken when

I saw it. A shaft from the engine leads into an adjoining room in which are six dynamos, each capable when worked to its full power, of feeding sixty Swan lamps. They are driven at 1600 revolutions per minute. The E.M.F. is low, being about sixty volts.

The current from this machine varies with the number of lights in use, but must usually be about 240 ampères. It is led into two large mains, each consisting of 19 wires apparently of No. 9 Birmingham wire gauge, presenting an area equal to that of a wire rather more than one-third of a square inch in sectional area. These wires are thickly coated with composition and tape windings so as to be altogether nearly 1½ inch in diameter,

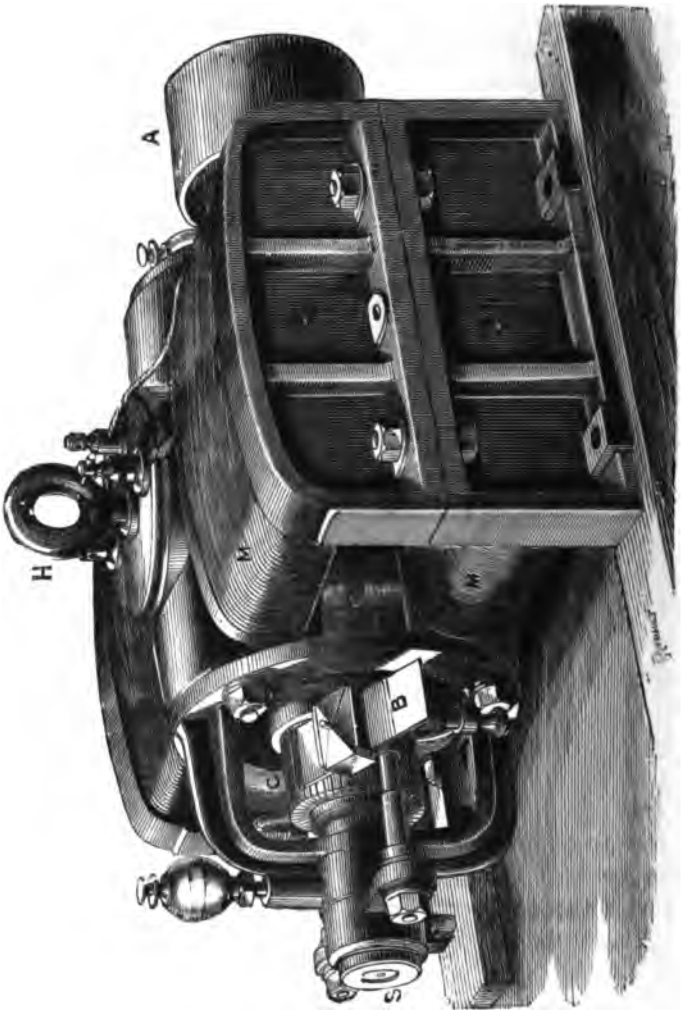

Fig. 43.

and laid in a wood trough filled up with pitch composition. At present* about 250 Swan lamps have been fitted in the building of twenty candle-lights (nominal) each. About 200 of these are generally used at the same time. The working has been exceedingly steady and good, and the wear of the Swan lamps has not exceeded its usual average. It is proposed to light the central hall with six arc lights on a new system, designed by the manager of Mr. Crompton's works, and for this purpose two more smaller dynamos will be added to those at present in use.

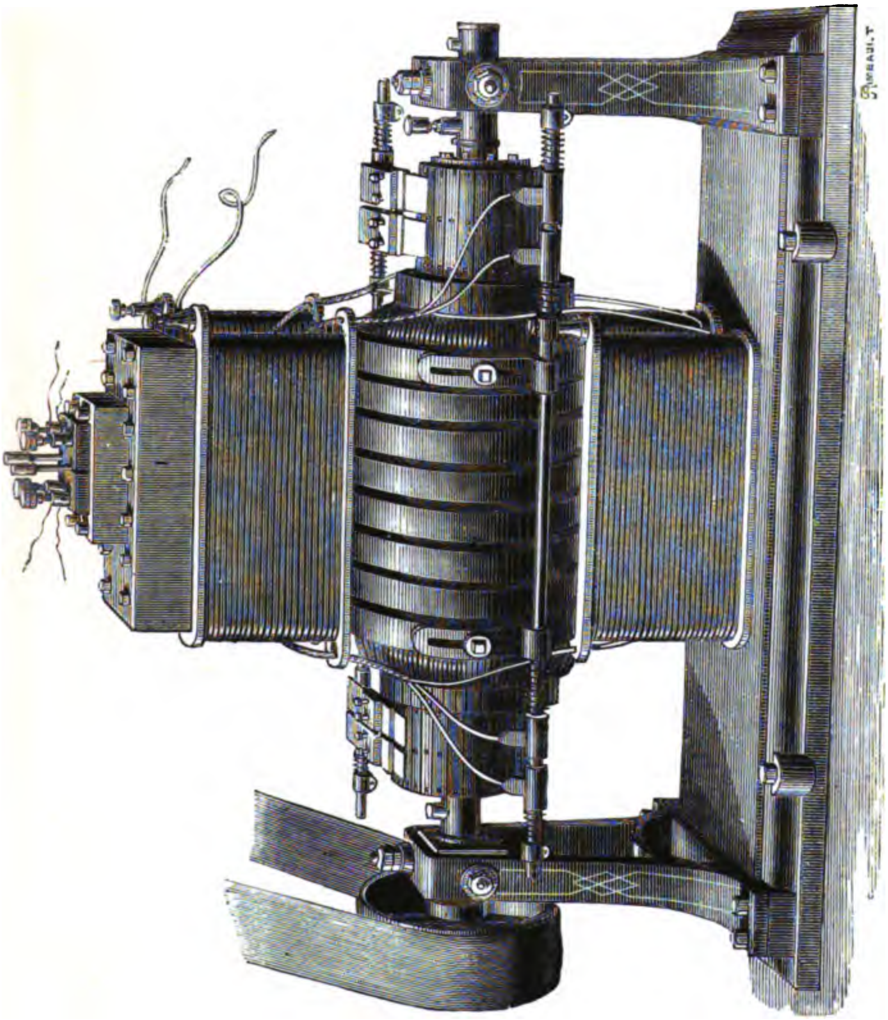

FIG. 44.

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* Since the above was written, 350 lamps have been fitted up, and the number of dynamos is about to be increased to eight.

The Maxim Dynamo.

Very similar to the Gramme machine is the Maxim generator (Fig. 44). In fact the only important difference is that in the Maxim generator the ring is very elongated (Fig. 42).

A peculiarity of the Maxim machine is, that it has a regulator, whereby when the current rises or falls above or below a certain amount, an apparatus comes into play, worked by an electro-magnet, which alters the position of the brushes, thus causing more or less electricity to pass. For, as we have seen, the position of the brushes is one of the most important points in a dynamo, and determines the flow of the current. These machines are not much used. They are the property of the Maxim Weston Company.

Page 213.

The Weston Dynamo

See sec. 5, page 229.

Consists of two field magnets arranged as in the Gramme machine. The armature (Fig. 45) is of the longitudinally wound type, and consists of a great number of iron-toothed wheels (Fig. 46), placed side by side on an axle so as to form a cylindrical drum, with ribs along its surface. These wheels are insulated one from another so as to prevent the formation of local currents in the iron. Wire is then wound along the drum parallel to the axis, carried over the ends of the cylinder, and so round and round, the ends of each section being brought to a copper commutator furnished with proper brushes (Figs. 45 and 46). The

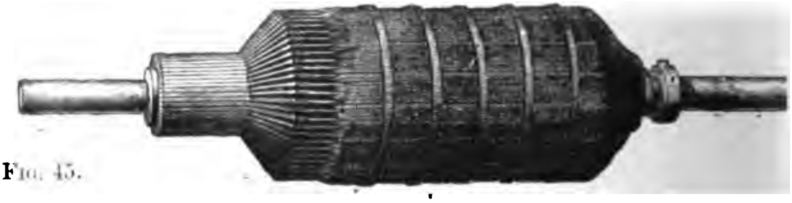

Fig. 45.

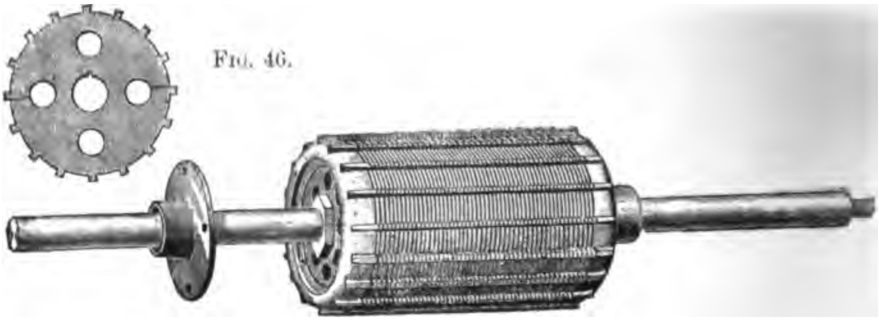

Fig. 46.

field magnets are shunt wound, taking only about five per cent. of the main current.

Considering the high efficiency of these machines, it is remarkable that they have not had a wider sale in this country. They are manufactured at present in America, and are in considerable use there. In England they are sold by the Maxim Weston Company.

The Gülcher Dynamo.

This is another modification of the Gramme, but possesses some peculiarity in the mode of winding the magnets. From a "No. 4" machine, about four feet in length and two in height the result of Mr. Gülcher's trials appears to be that at about 750 revolutions per minute, and with an expenditure of 13½ horse-power on the axle of the dynamo they give a current of 120 ampères at an E.M.F. of sixty volts. This would give about 540 volt-ampères per horse-power. But something further must be subtracted for loss in belting, so that to run the machine more than 13½ horse-power would have to be expended in the cylinder of the engine; and I understand the above calculations to be based on theory rather than on actual measurements in practice.

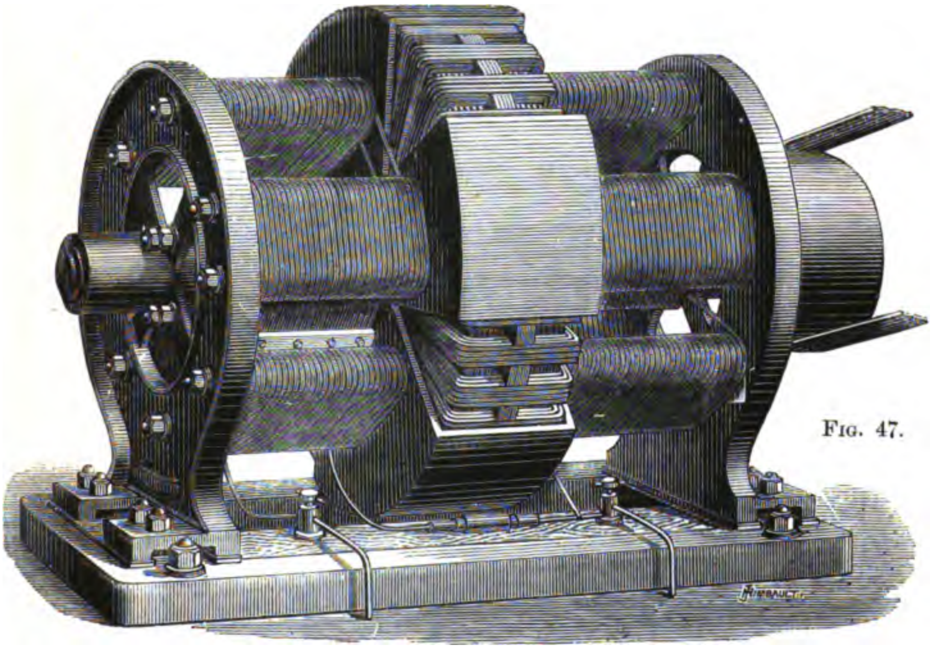

FIG. 47.

This machine is the property of the Gülcher Electric Light and Power Company.

The Schückert Machine

Is another modification of the Gramme. It is represented in Fig. 48.

According to an account published in the *Electrician*, the electromotive force is arranged at 110 volts, and the machines vary from one horse-power to eleven horse-power. Their average efficiency appears to be from 450 to 500 volt-ampères per horse-power. They have been chiefly tried with Edison lamps, at Schückert's factory, and are said to give about 6½ Edison A. (16-candle) lamps per horse-power (see the *Electrician*, February 3rd, 1883, p. 269). This is considerably below the figures claimed for other machines. These machines are also in use by the Pilsen-Joel Company, in Holborn. A nominal twelve horse-power engine, apparently working at about twenty-four horse-power, is driving one large Schückert, one small ditto, and a small Siemens. The large machine has an E.M.F. of 800 volts (nominal). Its speed is 600 revolutions per minute, giving a current of 8.5 ampères, as shown by an ammeter, and lighting fourteen Pilsen-Joel arc lights in various shops in the neighbourhood, at a cost of £30 to £35 per annum for each light. The resistance of the machine is about six ohms, and of each lamp is about six ohms also. The lamps are in series, hence the practical E.M.F. must be about 8.5 ampères × (14 × 6 + 6) ohms = 765 volts.

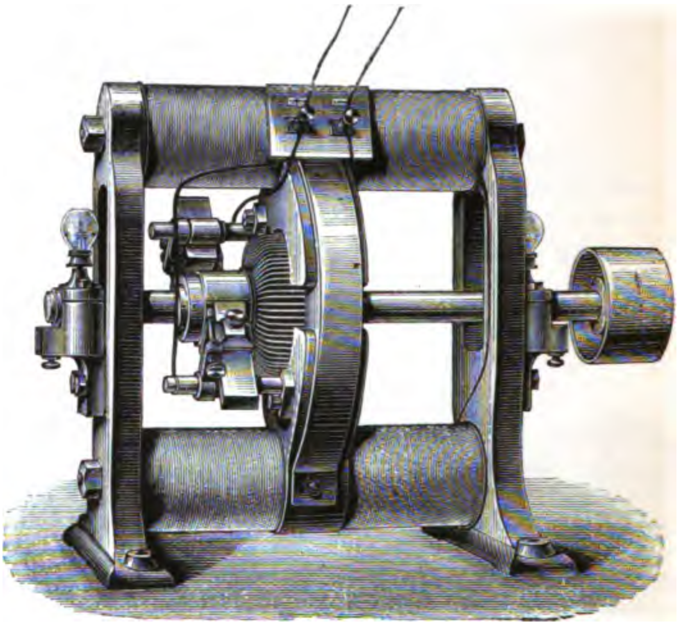

FIG. 48.

The smaller machine has a nominal E.M.F. of 400 volts, and lights six Pilsen-Joel lights. Its energy is about half the large one, while the Siemens at about 900 revolutions per minute gives an E.M.F. of about eighty volts, which lights thirty-two Gatehouse lamps, with a current of about forty ampères. The total energy of these machines appears therefore to be rather less than 13,000 volt-ampères, that is about 500 volt-ampères to the horse-power. The coils of the field magnets are remarkably cool, and there is but little sparking. The machine's lamps and wires are so carefully insulated from the earth, that even at the high E.M.F. of 800 volts, parts of the lamps may be touched with one hand with safety, but of course the main wires ought not to be handled. The lights appear to burn very steadily.

SEC. 4.—*Drum Armature Machines.*

Machines of this class have coils of wire wound lengthwise round a drum placed upon a spindle. The theory of them is shown in Fig. 49. As the spindle *a*, *b* revolves the wire *c*, *d*, *e*, *f*, *g*, *h* also revolves with it, cutting the lines of force between N. and S. and generating the currents shown by the arrows. Compare Fig. 12. A reversal of direction of course takes place at points midway between the poles, that is when the coil is in a vertical position, and the reversed currents are collected by a commutator.

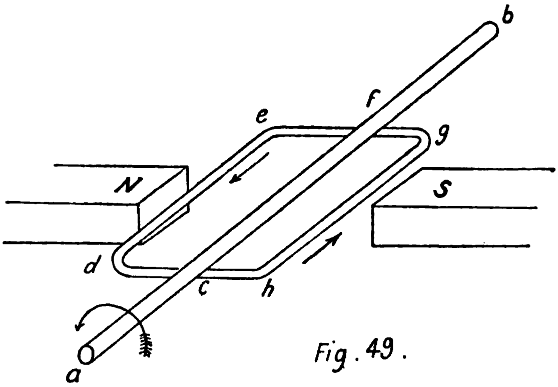

Fig. 49.

The Siemens Dynamo.

Of drum armatures the best known in this country and the earliest in date, is the excellent Siemens machine, which for practical work, especially on a small scale, is surpassed by none.

The armature consists of a drum or cylinder of wood about twice as long as it is wide; on this cylinder iron wire is wound in several layers, so as to cover the surface. Coils of wire are then wound longitudinally around this till it is completely covered. The ends of each coil are brought out to the segments of commutators on opposite sides of the axle, in a manner somewhat complicated. The field-magnets embrace the armature in much the same manner as the Bürgin machine. They are split up into lengths as shown in Fig. 50, in order to avoid local currents in them, to increase their strength, and afford ventilation. These machines are sometimes also made vertical, as in Fig. 51.

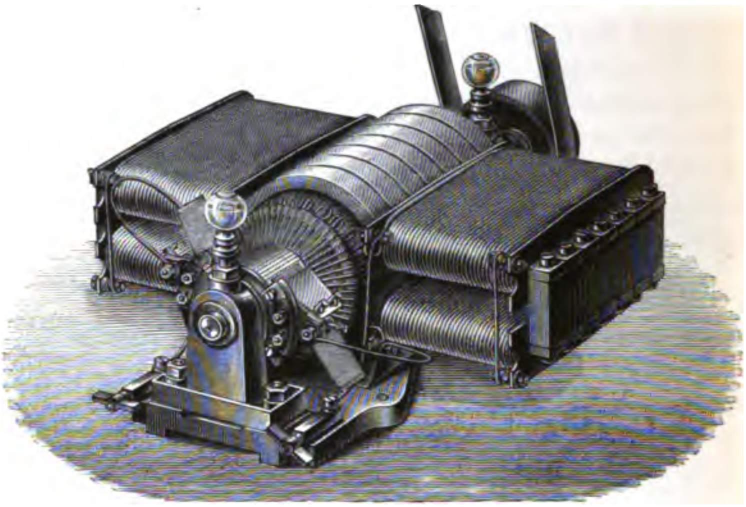

FIG. 50.

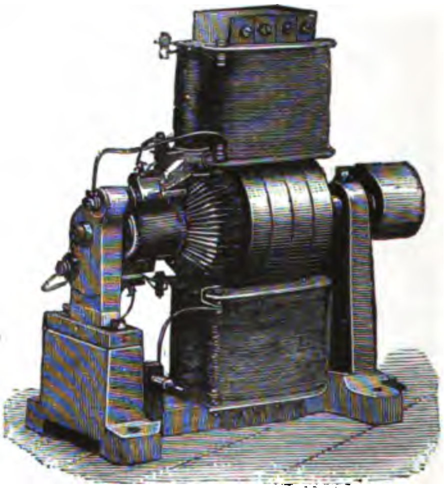

FIG. 51.

Messrs. Siemens have also an alternating current machine, shown at Fig. 52. It consists of two "crowns" of field magnets bolted to two vertical rings fixed on to a base plate. These magnets are covered with the coils through which a direct current is passed from a separate direct current machine. Between the crowns a wheel revolves, carrying coils of wire wound on wooden cores. The current is drawn off from the armature coils by four revolving copper cams fixed to the axle of the revolving-wheel carrying the field-magnets. There is no iron in the armature. The current is of course of an alternating character.

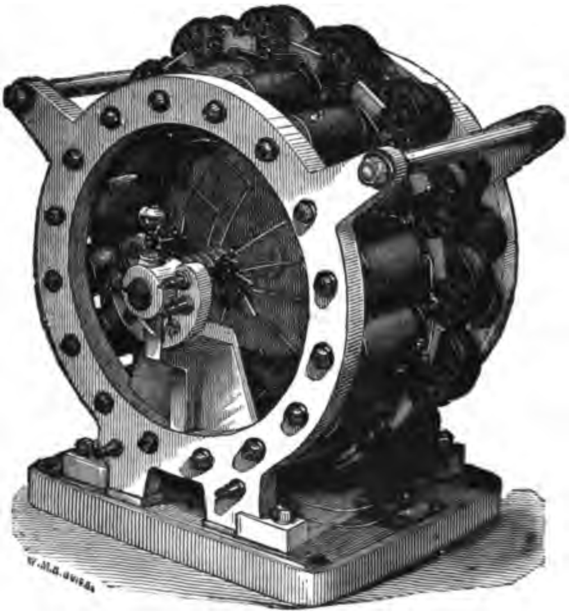

FIG. 52.

This machine offers the great advantage that its armature coils may be united up in any desired manner by proper attachment to the revolving cams.

It is a great advantage in all separately excited dynamos to use as an exciter a totally distinct machine, driven, if possible, by a separate belt and pully. By this means perhaps a little power is wasted, but great facility of arrangement is gained, as the respective speeds of the dynamo and exciter may be arranged in any desired manner.

The Siemens machine is in use for lighting part of the town of Godalming, It is driven by water power. The cost of lighting is rather less than that of gas; but the lighting is done by contract, and I am not aware whether Messrs. Siemens have lost or gained by the transaction. I believe the rate charged is 2*l.* per incandescent (20-candle) lamp per annum, and about 28*l.* for arc lights.

The Siemens alternating machine has been in use at the Savoy Theatre for some time, and has been a great success. There are 1200 20-candle lamps in use, viz., 150 in the auditorium, 824 on the stage, 220 in the dressing-rooms and passages, and eight in the engine room, as indications to the engine drivers of the state of the various circuits. They are arranged in six circuits, each worked by an alternating dynamo. The dynamos are driven by two 20-H.P. and one 12-H.P. engine (nominal). The E.M.F. is about ninety volts, and the engines probably expend from 120-130 horse-power. The lights are not all worked at once, and are run under the 20-candle power.

One spare dynamo is always kept in readiness in case of accidents, and an extra direct-current dynamo is in use to charge the storage batteries—forty in number—and each 4″ × 3″ × 2″ in size, which are used to light the lamps on the heads of the fairies. These lamps are about the size of a hazle nut. They require an E.M.F. of about two or three volts, and give about a candle power. They are fixed to combs in the hair of the actresses, and the storage batteries are attached to the centre of their backs by means of long iron hooks and eyes.

The Edison Machine.

The Edison machine is chiefly remarkable for the immense length of its electro-magnets. The advisability of these has been doubted. They terminate in large blocks of soft iron. The armature is longitudinally wound. In the big machines the armature coils consist of sectional square bars of copper, separated from one another by brown paper, and united into a continuous coil by discs of copper placed in the axis.

There is thus very little internal resistance. The machines are made all sizes. The largest machines work the best. Fig. 53 gives a view of the medium sizes, showing the long magnets, the armature at the bottom, the commutators, and a lamp to light the machine and show that it is working properly.

In a cellar below the premises of the Edison Company in the Holborn Viaduct are two enormous Edison machines, each about 7 ft. high by 9 ft. long by 7 ft. wide. These are driven by an engine working directly on the axle of the armature, which is

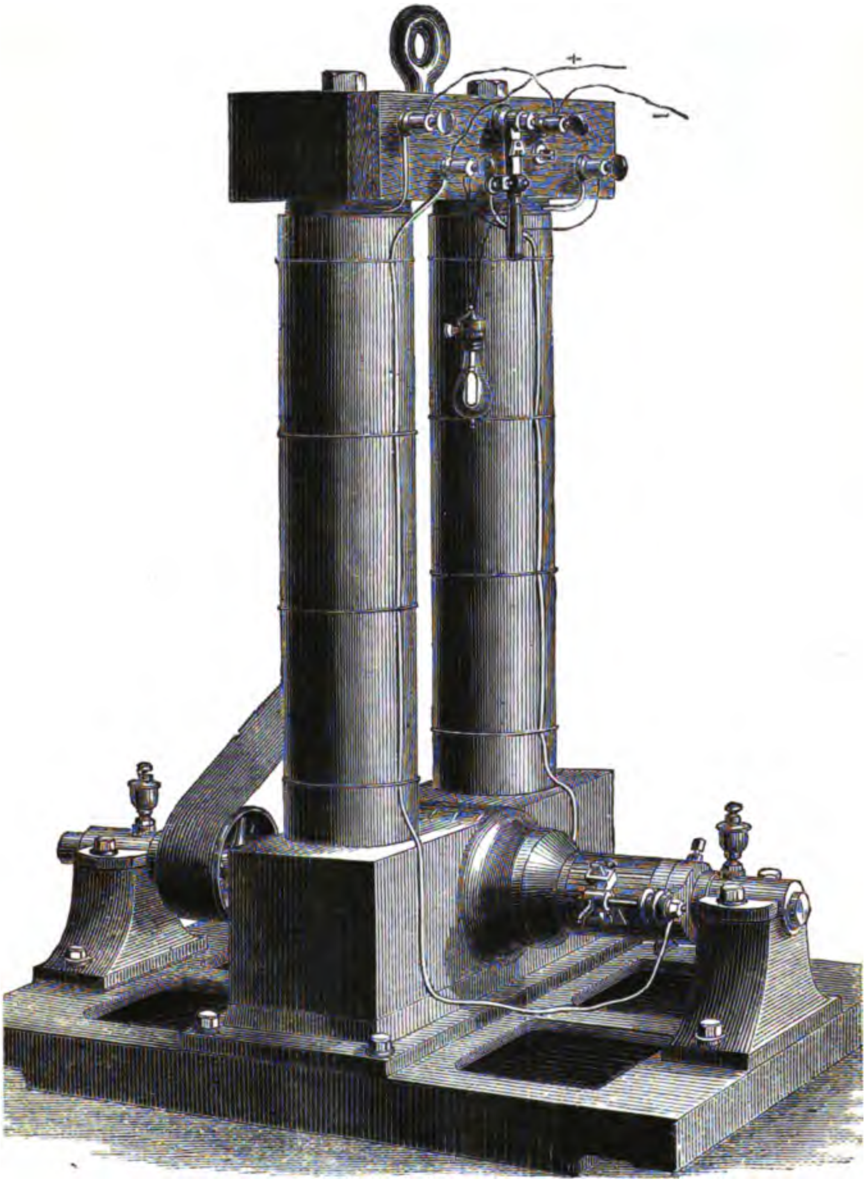

Fig. 53.

driven at 300 revolutions per minute. The field magnets consist of twelve long bars wound with wire, of about six ohms total resistance, and terminating in huge masses of iron surrounding the rotating armature. The electromotive force of the machine is about 110 volts, and at about 110 horse-power of work it lights 313 95-volt lamps, and 484 107-volt lamps, all of about sixteen candle power. They are situated at the Imperial Hotel, and a number of restaurants and shops in the neighbourhood. The lamps are burning very well near the engine, but some of those in the buildings are not so bright. Nevertheless, the result is a good one, giving nearly eight good lamps to the H.P. The engines and boilers and dynamo, are all of American make, and seem to be very satisfactory. The total energy expended must be about 60,000 volt-ampères, or about 550 to the H.P.

The Ferranti-Thompson Machine.

The Ferranti-Thompson dynamo is of so peculiar a type as to merit special mention. In form it closely resembles the Siemens alternating dynamo, see Fig. 52. The armature, like that of the Siemens machine, contains no iron, and carries a ribbon of copper, 120 feet long and half an inch wide, wound round and bent up into the shape of a star with 8 or 16 points (see Fig. 55). It is mounted on a spindle in as light a manner as possible. The field in which it rotates consists of two "crowns" of magnets, arranged on each side of it, with their north and south poles presented alternately (Fig. 55). As the star armature is only half an inch wide, a very intense field of force is thus created across the poles of these field magnets. As the armature revolves, the copper ribbon cuts the

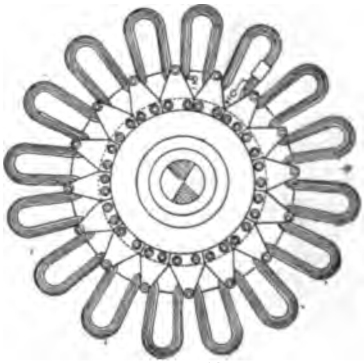

Fig. 54.

lines of force, which fall alternately on its right hand and left hand as it rotates; currents are therefore generated in the ribbon in rapidly alternating directions, and are led off to the axle of the armature, where they are received from a sort of cam by a brush arranged for the purpose. In order to get an effect, it is necessary to drive the machine at from 1500 to 2000 revolutions per minute. This great speed is a great disadvantage, as it must greatly strain the belting and tend to wear out the spindles. At present the machine is at work at the Aquarium. It is driven by a semi-portable engine of sixteen horse-power nominal. It is impossible to say what the actual work being done by this engine is. As the current is alternating, it cannot be used to excite the field magnets, and therefore a small Siemens' machine is used for this purpose, which requires about two horse-power. The machine is at present used to light 340 Swan lamps of resistance 31.5 ohms when hot, and wanting a current of 1.3 ampères, with an electromotive force of 41 volts each. This would thus require a total current equivalent to 18,000 volt-ampères to light the lamps up to twenty candle power. From the look of the lamps when I last saw them I should imagine they are burning at about twelve-candle power, and therefore not in a very economical manner, and that the current is therefore actually about (say) 12,000 volt-ampères. If the engine be taken as working at 25 horse-power,

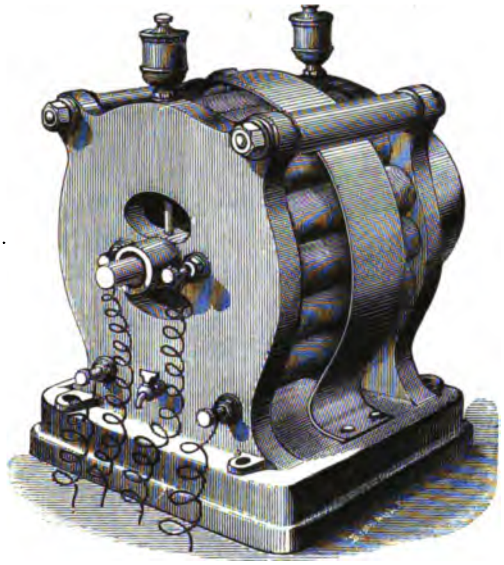

FIG. 55.

which I suspect is a low estimate, this would give somewhat less than 500 volt-ampères per horse-power. But these figures are mere guesses, for as yet it does not appear that any exact measurements have been made.

The remarkable point about this machine is its very small size and weight, as compared with the work it will do. It will be difficult to build it larger, because at its great speed of rotation at the circumference of the armature, any metal used in the armature would cause the generation of very great local currents, and without the use of some metal such as steel it is hard to see how sufficient strength can be obtained to resist the enormous centrifugal force which large armatures have at speeds so great as are necessary to generate currents in armatures without the aid of iron.

The Elphinstone-Vincent Machine.

Lord Elphinstone and Mr. Vincent have devised a dynamo, with the field magnets arranged in the form of an equilateral triangle, in the centre of which a drum-armature revolves, within which are other fixed field magnets. An intense field is thus created. It is in use at the Reform Club, with Woodhouse and Rawson's lamps. The number of lights at the Reform Club is forty-six 20-candle, the E.M.F. is forty-three volts, and the total current required is therefore probably about sixty ampères. The engine is supposed to be doing from four to five horse-power. One of the special advantages claimed for this machine is the ease with which the current and E.M.F. can be altered to suit the needs of the work that has to be done.

CHAPTER III.

ELECTRIC LAMPS.

We now pass to the mode in which the electricity thus generated is made to give light.

Carbon is a substance which exists in nature in very varied forms and combinations,—as coal; the material used in pencils commonly called black lead; charcoal; graphite; the substance found in the interior of gas retorts; and the diamond. Carbon may be either very hard or very soft: the diamond is the hardest substance known,—a piece of soft wood charcoal crumbles at a touch. Carbon is a conductor of electricity, but a bad one. The softer kinds burn in air; the harder kinds burn with difficulty in air, though with ease in oxygen. It is carbon in a state of white heat that is commonly used for electric lighting.

There are two distinct modes of lighting, known as the arc and incandescent systems.

Sec. 1.—Arc Lights.

In 1810 Davy discovered that if an electric current of considerable quantity passed through two pieces of carbon in contact, on separating them slightly a glowing arc was formed between them. If by any means the arc became interrupted, the current ceased to flow till the carbons were again united and separated. This must not be confounded with the electric spark. A spark will pass between conductors of any material, but it will only leap over a very small interval, unless the electromotive force is enormous. A battery of 100 Grove's cells, with an electromotive force of 200 volts, would not yield a current of sufficient electromotive force to dart over an air-space 1-20th of an inch wide; but it would yield a magnificent arc light. While the arc exists the carbons are slowly oxydised by the air and burned away. Disintegration also takes place. It therefore becomes a problem for the inventor,—first, to manufacture carbons of even size and pure hard quality; and, second, to contrive a mechanical arrangement which will not only bring them slowly together as they waste away, but also, if by any means the current is interrupted and the arc ceases to flow, shall instantly bring them into contact, and then separate them to the proper extent.

The manufacture of carbons is now a separate branch of industry. The principles involved in it are chiefly the selection of good gas carbon, the grinding it to powder, the mixing it with some glutinous substance such as sugar-syrup, the casting it into moulds or forcing it through dies, and the final hardening it into smooth black uniform sticks of various diameters, that when struck, give a metallic ringing sound like a piece of steel. These carbons are made of various sizes, from 1½ inches in diameter downwards, and of various lengths.

The modes in which they are mechanically brought into contact are so varied and complicated that it would be quite bewildering to attempt to describe them here. The reader is referred for a description of them to the work of Mr. Dredge, already mentioned, where they are most elaborately dealt with. It may be enough to say that the principle of the greater number of them is as follows:—a lower carbon A is fixed in position in a socket, and above it a second carbon B is vertically suspended; the current is then sent through the carbons. As long as the carbons are in actual contact, the current will pass to the full extent permitted by the resistance of the carbon. There will, therefore, be a very strong current. This current is passed round a coil C surrounding a piece of iron, which it immediately makes magnetic; thereupon a lever D is attracted to the electro-magnet. This lever is provided with some form of hook or clutch which

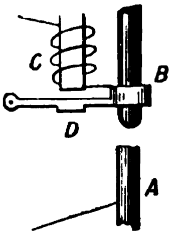

Fig. 56.

enables it to seize the upper moveable carbon and drag it away from the lower one. The result is an arc light between A and B. The current is thereby much weakened, because the resistance offered by the arc to its passage is much greater than when the carbons were together. Now, if from any accidental cause the arc light ceases, the current immediately becomes weaker, or stops. But the iron then becomes less magnetic, the lever D is released, and the rod of carbon B falls back towards A. But directly this takes place the current flows again at its former strength, the lever C is dragged up, the carbons separated, and the arc flows until some accident causes it to be broken, when the operation described above is repeated.

Upon these principles, or principles like these, we have lamps devised by Messrs. Debosq, Serrin, Crompton, Brockie, Gramme, Siemens, Wallace, Brush, Weston, Krizich and Piette (the Pilsen system), and many others. The carbons are almost always vertical. This is because the radiation of light from a pair of carbons is not uniform over a sphere, but is of such a kind that the greatest advantage is got by putting the carbons vertical. Indeed, this may be seen from the representation of the burning carbon points

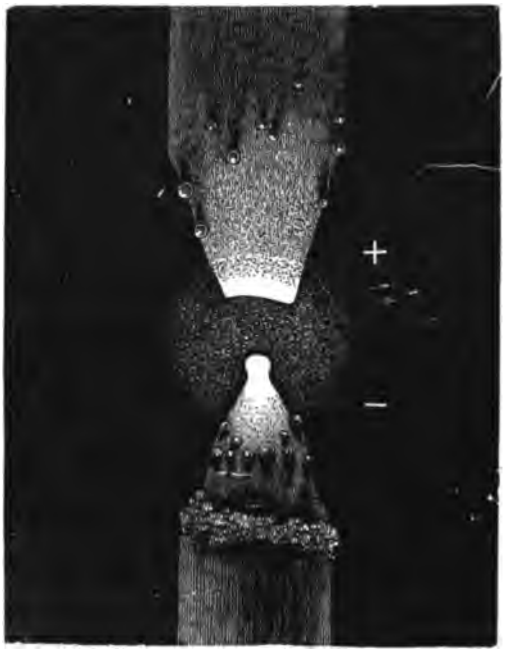

FIG. 57.

given at Fig. 57. Moreover, when placed horizontal, an upward current of air acts on the flame and turns it into a true arc like a bow; much impairing its efficiency.

In addition to the ordinary arc light, Jablochkoff has designed an ingenious form of electric candle. His invention consists in placing the carbons side by side with a partition of plaster-like composition between them. The arc then glows across the partition, which burns slowly away with the carbons. But it will at once be seen that with such a system it is of vital importance that the carbons should burn with exact uniformity. For if one burns faster than another the arc would go out. As a fact, the carbon attached to the positive pole burns away just about twice as fast as that attached to the negative pole. This difficulty was met at first by making the positive carbon twice as large as the negative. The difficulty is, however, now surmounted by the use of an alternating current, which, of course, acts uniformly on the two carbons.

Other systems have also been tried, though they are not in great use. Thus the Werderman-Reynier principle causes a stick of carbon to press vertically upwards against a carbon slab. A minute arc or red-hot glow is thus formed, and the stick of carbon slowly wastes away.

Or, again, sometimes a mass of marble or other refractory substance is placed in the arc and made to glow with a white-hot heat, as in the Lampe de Soleil, or Sun-Light Lamp.

The arc lamps, however, most in use are some well-known type of ordinary arc light, as the Siemens, or the Brush, or Pilsen, or Crompton. The arc light has one great advantage, viz., that for a given amount of electrical energy it gives about four times the light that the incandescent system will afford, but it has many disadvantages. It requires constant changes of carbon every day. It gives a white, glaring, unpleasant, and even ghastly light. It flickers constantly, blinks, and often goes out for an instant, and it is also so intense that it is painful to the eye. These great disadvantages have turned the attention of inventors to incandescent lighting.

SEC. 2.—*Incandescent Lamps.*

It has before been shown that when an electric current is urged through any circuit consisting of any number of resistances arranged in any order, the whole energy of the circuit is expended in doing work in the various parts. The current, as has been said, will be the same throughout the system, but the energy expended in each part is proportional to the resistance of that part. This follows from the law, that the current in each part must always be the same all round the circuit. For suppose that a circuit consisted of the parts X, Y, Z, with resistances x, y, z respectively, and that the current flowing round the system $= C$. The electromotive force at different parts of the circuit will of course vary. Let E' be the electromotive force between the two ends of X, E'', the E.M.F. between the two ends of Y, and E''' the E.M.F. between the two ends of Z. Then the energy expended in X will be $E' \times C$. But by Ohm's law

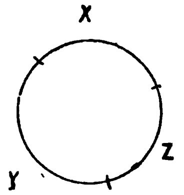

FIG. 58.

$E = C x$. Hence energy expended in $X = C \times C x = C^2 x$, and the energy in Y is $C^2 y$, and that in Z is $C^2 z$; the total energy being $C^2 (x + y + z) = C (E' + E'' + E''')$. This shows that the amounts of energy exerted in the parts of the circuit X, Y, Z respectively, are proportional to the resistances in those parts. And all this energy is expended in doing work; it may be in heating the wires; it may be in causing magnets to move masses of iron; it may be in sound, or in light, or in chemical action.

From this it follows that in those parts in which we desire energy to be expended, we should have high resistances, in the others low resistances. Thus, for example, we should desire a low resistance in the dynamo and conducting wires; for all work done there is not only wasted, but actually impairs the machine.

In general when electricity is simply sent through a wire it heats the wire. Thus, for example, if a current of 1½ ampères at 50 volts were passing through a round copper wire one mile long and .1 in. in diameter, having thus about six ohms resistance, the wire would be heated. The heat would not be appreciable, yet it would be there, distributed over the whole length of the wire. Now, if we were to substitute for this wire a short length of thin wire of a resistance also of six ohms, say 4 ft. of German silver wire .01 in. in diameter, the same amount of heat as was previously distributed over the five miles would be concentrated in the 4 ft. of wire, which would become very hot. Again, if for the 4 ft. we substitute 4 in., not of wire, for it would have to be made too thin to offer the same resistance, but of some bad conductor, such as carbon, then the current would raise it to a brilliant white hot glow. This, if the carbon were in the open air, would only last an instant. For white hot carbon, like coal, instantly burns out by uniting with the oxygen of the atmosphere. To prevent this combustion it would be necessary to enclose the carbon in a vacuum, or in some special gas. This is accomplished by surrounding it with a glass bulb, from which the air is exhausted, and into which the wires carrying the current are hermetically sealed. We have here an incandescent lamp. The manufacture of these lamps is a matter of great experience and difficulty. To commence with, some metal must be found which, when hermetically sealed into the glass, will not crack it by the expansion produced by the heat of the lamp being different from the expansion of the glass. Platinum is used for this purpose. Next, a suitable form of carbon must be obtained or artificially prepared. This filament of carbon, in order to have the necessary resistance, must be as fine as ordinary sewing thread. If not perfectly uniform, then the thinner parts will have the greatest resistance. As a consequence, these thinner parts will become hotter than the thicker parts. The carbon will then be over-heated in one place and under-heated in another, and therefore is sure soon to give way.

Again, it is found that metals and carbon, when exposed to the air, absorb it. They become, in fact, "wet" with air, just as with water. A piece of carbon that is left long in the air becomes soaked with air, like a sponge. When a piece of metal is lifted out of water the water is not all left behind, a film adheres to the metal, which must be removed by wiping or by evaporation. And so when a piece of metal which has been in air is placed in a vacuum, the air still tends by cohesion to cling to the metal and soaks into it. This presents another difficulty in the manufacture of incandescent lamps. Moreover, all air is moist, and as water contains oxygen, all traces of moisture must be removed from the interior of an incandescent lamp.

There appears to be no very great inherent superiority of one form of lamp over any others; the true secret consists in attention to small details and systematic and careful manufacture. As a rule, lamps with low resistance and thick filaments, and which are not raised to a very high degree of incandescence, last the longest; but, on the other hand, they take rather a greater proportionate energy of current to yield the same amount of light. Hence, though economical in point of durability, they are not so economical in point of light-giving power. The present tendency is to increase the resistance of lamps. Thus efficiency is gained, while increased skill in manufacture keeps the durability of the lamps about the same. In using incandescent lamps, care should be taken never to heat them much above their nominal power, and indeed it is better to work them rather under this point. There is an impression in some quarters that alternating currents wear incandescent lamps out slower than continous currents. I am assured by experienced persons that this is an error; the rate is about the same. But a peculiar fact is stated to be observable, viz., that incandescent lamps worked by alternating currents always give way in the middle of the carbon filament, whereas incandescent lamps lit by direct currents give way at one of the extremities of the carbon, it being found in practice that the positive pole is perceptibly hotter than the negative. For this reason where direct currents are employed it is recommended to reverse the current every day or two, and thus wear the lamp as evenly as possible.

It is not my purpose to describe in detail the mode of making incandescent lamps, I only propose to indicate the general principles upon which the manufacture proceeds. A bulb is first blown in the centre of a glass tube. Into a second tube, or piece of glass, two pieces of wire are then mechanically sealed, and the strip of carbon is attached to their ends (Fig. 59). The second

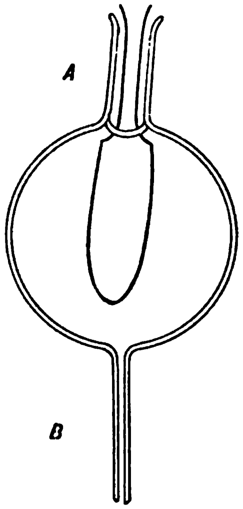

Fig. 59.

tube is then melted firmly into the upper end A of the first, as shown in the figure. The air is then exhausted through the lower tube B, and in order to get rid of the remaining air clinging round the carbon and wires, the lamp is heated with a current after nearly all the air has been removed, the process of exhaustion going on all the while. As soon as the air has been completely exhausted, the end of the tube B is melted and drawn off. The filaments of carbon in the Swan lamp are made of thread, carbonised by sulphuric acid. Those in the Edison lamp are made of strips of bamboo cane. Lane-Fox's filaments are made of twigs of the grass used in making carpet brooms, and Maxim's are composed of carbonised paper of good quality. But as soon as these carbons have been made, their resistance is sure to be different at different parts. To equalise them, a very ingenious process is resorted to. They are placed in some gas or vapour rich in carbon, such as coal gas or naphtha vapour, and strongly heated with an electric current. As the filament becomes hot, the carbon in the gas is decomposed, and tends to settle on the carbon filament, being deposited most rapidly on the hottest Page 242. parts. But, as was explained before, the hottest parts are precisely those upon which it is most desirable to have a deposit. Hence, therefore, if this operation be continued for some time, the irregularities in the carbon will be cured, and the whole filament rendered uniform throughout.

The various kinds of lamp in use may immediately be known by observing the shape of the glass bulbs and the carbons within them; some of them are shown in Fig. 60. The lamps at present

A Trade No. of Lamp.	B Nominal Candle Power.	C Resistance in ohms when cold.	D Resistance in ohms when hot.	E Current required to light to its proper candle power ampères.	F E.M.F. necessary to produce this current, volts.	G Energy required per lamp in volt-ampères.
A_3	16	36	23	1.6	37	59.2
A_2	16	40	25	1.51	39	59
A_1	18	47	28	1.46	41	60
A	18	56	31.6	1.36	43	58.5
B_1	20	61	34.9	1.32	46	60.7
B	20	70	36.9	1.3	48	62.5
C	20	72	39.4	1.27	50	63.5
D	20	74	41.3	1.26	52	65.5
E	20	75	43.5	1.24	54	66.9
F	20	76	45.6	1.23	56	61.8
G	20	81	48.4	1.22	59	72
H	20	86	50.9	1.18	60	70.8
I	20	88	55.5	1.17	65	76

most in use in England are those of Mr. Swan. They are made in various patterns, of which the table on the preceding page is a list of those chiefly in use, with their resistances, the current required to light them to their proper working point, and the electromotive forces necessary in each case to drive the required current through the lamps. The resistances when cold are of course of no interest, as the resistance of the carbon when heated diminishes very greatly. It is the hot resistance that must be reckoned when computing the electromotive force required for the lamps.

There is also a twenty-candle lamp of 100 ohms resistance which will shortly be brought out; and lamps of other powers, as five, ten, and fifty candles are also made. Column D is of course got by dividing column F by E, according to Ohm's law; and column G by multiplying E and F together to get the energy.

From the last column it would appear as though the lower powers of twenty-candle lamps were the most economical, as requiring the least energy to light them. But this is not so. In practice the higher resistance lamps are the most economical, though they hardly last so well. The figures in column B are only the nominal candle powers, and the actual lamps vary somewhat from them. The price of a twenty-candle Swan lamp is 5s. The average duration of a Swan lamp, if well treated, is said to be about 1200 hours. Some burn longer than this, but I believe this is about the average. If, however, as is often the case, the lamps are heated above their nominal power, they do not last nearly so long.

The corresponding Table for the Edison light, as published by the Edison Company, is as follows:—

Trade No.	Candle Power.	Resistance when cold, ohms.	Resistance when hot, ohms.	Current required, ampères.	Electromotive Force necessary, volts.	Volt-ampères per Lamp.
B	8	112	70	.75	53	39.75
,,	10	420	272	.4	107	42.8
A	16	259	168	.63	107	67.4
,,	32	155	96	1.11	107	118

The figures in the last column seem high in comparison to the candle-power of the lamps, but it is said that the real candle-power afforded by these lamps is greater in proportion to their nominal candle-power than the lamps of other makers. The lamps are alleged to last about 1000 hours. They cost 3s. 6d.

The Maxim incandescent lamps are of two sizes, the data for

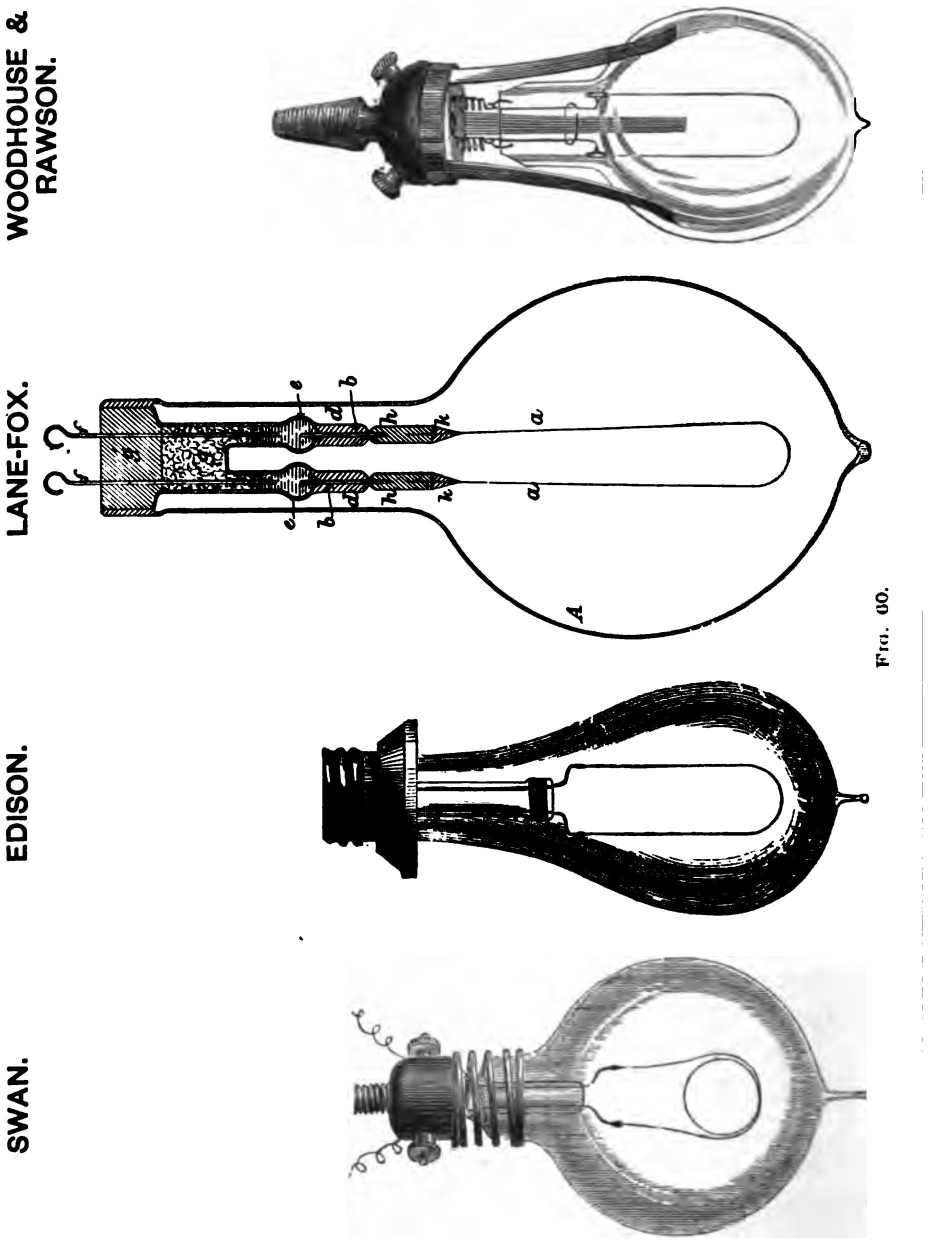

FIG. 80.

which are stated to be about as follow (though no very recent experiments appear to have been made):—

Candle Power (nominal).	Resistance when hot (ohms).	Amount of current required, ampères.	Electromotive Force required, volts.	Energy required, volt-ampères.
50	35	1.8	63	113.4

These lamps have a very low resistance, hence they probably require a rather large proportion of energy to light them, but they are of excellent manufacture and last very well. Their price is from 6s. 6d. (Fig. 61.)

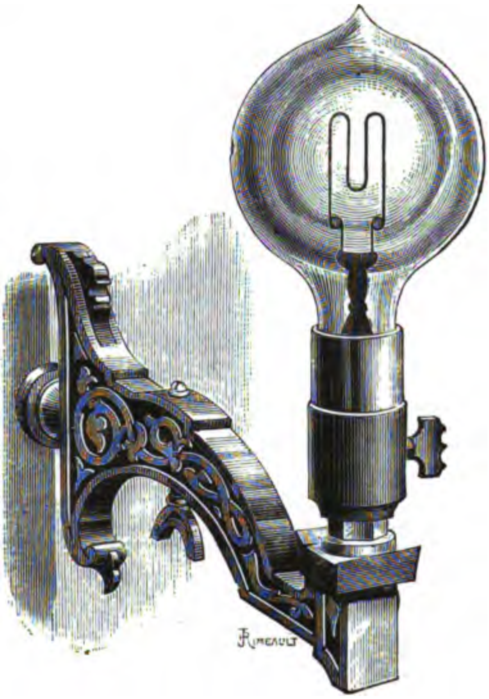

Fig. 61.

Mr. Lane-Fox was one of the earliest electric lamp makers in England. He first tried platimum threads, but abandoned them. His lamps are at present made by the Brush Companies.

The corresponding Table for Lane-Fox's lamps is as follows:—

Nominal Candle Power.	Cold resistance.	Hot resistance.	Current in ampères.	E.M.F. in volts.	Volt-ampères per Lamp.
18	88	48	1.24	60	74.4
18	50	27	1.65	45	76.5

The lamps of Messrs. Woodhouse and Rawson are of very good make. The details of their manufacture remain a secret at present. The form of the holder is peculiar, consisting of three strips of projecting brass. In making them no glass is inserted into the bulb, but the glass of the bulb is simply pinched and melted round the wires that carry the carbon.

The resistances of these lamps are as follow:—

No.* of Candle Power.	Cold Resistance in ohms.	Hot Resistance in ohms.	Current in ampères.	E.M.F. necessary, in volts.	Energy in watts or volt-ampères.
18 new filament	44	24.7	1.36	33.6	45.7
20	107	53.2	1.1	58.5	64.3
20	60	30.8	1.44	44.4	63.9
25	?	26.9	1.50	40.4	60.6
30	61	27.6	1.57	43.2	67.8

* Many other lamps are made of all kinds from 1 up to 100, but these are selected as the most usual patterns. The new filament of deposited carbon works better than those patterns previously in use.

Messrs. Woodhouse and Rawson have also made surgical lamps, of very minute size, which are chiefly used by dentists. A small battery is used to feed them. They are enclosed in tubes filled up with water, and are of the shapes shown in A, B, C, Fig. 62.

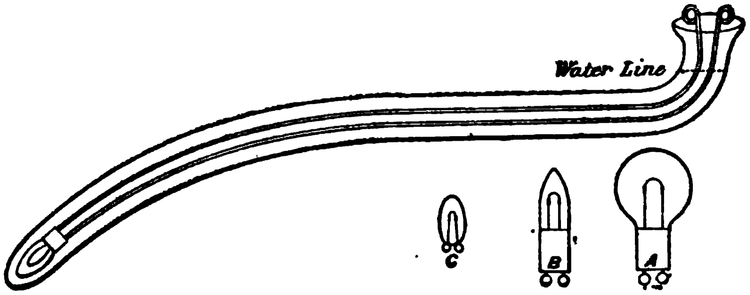

FIG. 62.

It were much to be wished that some series of thorough tests could be made with all the above various kinds of lamps. There are some others also in the market, as those of Gatehouse (20 candle-power, hot resistance = 40 ohms, current required .1.5 ampères, E.M.F. necessary to give this current, 60 volts, energy 90 volt-ampères.) Mr. Crookes has also designed a lamp which is manufactured by the Gülcher Company, but I am not aware that any details respecting it have been published, except what may be gathered from his patents.

Many patents have been taken out for holders to the various incandescent lamps, and for switches for turning them off and on. But none of them call for any special mention, being, in most instances, of very simple construction.

As any undue increase of current might be attended with fatal effect to the lamps, and if strong enough might even burn up the conducting wires, various forms of safety fuzes or plugs have been devised, the object of which is to cut off the current when it becomes too strong. These are described in the next chapter.

Page 253.

The globes of incandescent lamps are sometimes made of coloured glass, or are ground upon the surface so as to diffuse the light. In all cases light is rendered more pleasant by being diffused by a shade, but the waste of light is often very considerable. A beautiful illumination can be obtained by throwing a powerful light upwards on to a white ceiling, and allowing it to be diffused over the room, but the plan is rather wasteful.

CHAPTER IV.

ON CONDUCTORS.

THE resistance of copper is very slight, whereas the resistance of lamps is large. 1000 ft. of copper cable .3 in. in diameter, would not have a resistance of much more than $\frac{1}{10}$ ohm. A mile of No. 18 copper wire .049 in. in diameter, would have a resistance of 22½ ohms, but even a small incandescent lamp with a filament two inches long would have a resistance of 25 or 30 ohms when hot. As has been said, the energy of a current divides itself up in proportion to the resistances of the conductors; if therefore we had a single Swan lamp, fed by two No. 14 wires, each fifty feet long from the terminals of a machine, the resistance of the lamp would be (say) 30 ohms, that of the wires .1 ohm. Hence, the proportion of energy lost in the wires would be $\frac{1}{300}$. This seems small, and if instead of one lamp we were lighting 100, it might be thought that the loss from the wires would still be insignificant. A consideration of Ohm's law will, however, demonstrate that when lamps are arranged in parallel arc, the resistance of the wires becomes relatively very great. For suppose that from the terminals of a dynamo two cables proceed, each 125 yards long, and made of nineteen strands of No. 15 wires; 1000 yards of such a cable has a resistance of .313 ohms; let these terminals be conducted from the dynamo shed into a house, and from their termination let branch wires proceed, which for simplicity we shall suppose to lead separately to a number of incandescent lamps, as shown in Fig. 63.

Page 251.

Then the resistance of the two main wires would be $\frac{250}{1000} \times .313$ ohms $= .078$ ohms. The resistance of each lamp, of which we will suppose there are 100, with the wires taken to it, would be (say) 36 ohms. But since the 100 lamps are arranged in parallel circuits, there are 100 channels for the escape of the current, each channel having a resistance of 36 ohms. Therefore the total resistance of the lamps would be $\frac{36}{100} = .36$ ohms. A proper machine to work such lamps would be one having an

E.M.F. of about 50 volts, that being the proper amount for each lamp. The current would therefore be $C = \frac{\text{E.M.F.}}{\text{resistance}} = \frac{50}{.078 + .36} = \frac{50}{.438} = 114$ ampères, that is 1.14 ampères per lamp, and the energy required would be $E \times C = 50 \times 114 = 5700$ volt-ampères, or the equivalent of at least ten horse-power. Of this energy, the amount wasted in the wires as compared with that utilised in the lamps, would be in the ratio of .078 to .36, that is $\frac{2}{11}$ of the whole. Thus nearly one-fourth of the current would be wasted in the connexions. Now substitute a new dynamo with an E.M.F. of 100 volts. This would be too much for any one lamp. Hence we should now join our lamps in series of twos, of which there would be fifty. The resistance of the wires would be as before, but that of the lamps would now be $\frac{36 \times 2}{50} = 1.44$ ohms. The total energy required in the lamps would be the same as before, but the energy wasted in the connexions would now be to that used in the lamps only in the ratio of .078 to 1.44 or $\frac{1}{18}$ of the whole. It is therefore obvious (1) that with lamps in parallel arc, the conducting wires must be made as large as possible; and (2) that the higher the E.M.F. used, the greater will be the economy of the result, but a very high E.M.F. is considered dangerous, and forbidden by the Board of Trade. On the other hand, with a high E.M.F. the Page 141. conductors may be small, for the proportion of their resistance to that of the lamps will also be small. It is therefore of the greatest importance to bring the dynamo as near to its work as possible, if it is intended to light in parallel arc. And at present with a large installation in parallel arc the area could hardly well exceed a quarter of a mile, without very great waste, unless the mains were of enormous dimensions.

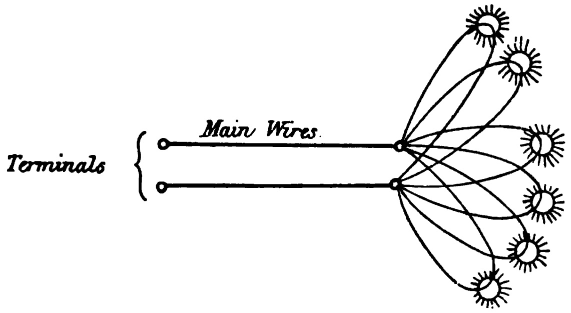

FIG. 63.

With series lighting on the contrary, the distances may be very considerable. For in this case the total resistance of the lamps arranged in series is high, and hence bears a large ratio to that of the conducting wires. Hence, for large and extended areas it is necessary to light with lamps in series, and to use high electromotive force; for lighting small areas, close to the dynamo, we may have low E.M.F. and lamps in parallel arc. Iron is sometimes used as a conductor; it is cheaper than copper, but requires to have an area of conductor about seven times as great, and hence wants a large amount of insulating material to cover it. Old rails could thus be used imbedded in troughs filled with pitch, but the making of joints would be troublesome. In the arrangement of installations, the great object is to keep the E.M.F. as constant as possible, no matter what number of lamps be turned on or off. Mr. Lane-Fox seems to have been one of the first to point this out. For if this is done, then any new lamp added in parallel arc at once draws its own proper current.

It has been said, that arc lights are usually low in resistance as compared with incandescent ones. For this reason it is more than ever difficult to run them in parallel arc, for the total resistance of the lamps would be almost as nothing compared with that of the conductors. Suppose that with an E.M.F. of 50 volts, we ran twenty arc lights of four ohms each, in single parallel arc. The resistance of the lamps would then be $\frac{4}{20}$ ohms = .02 ohms, but the resistance of the conducting wires even at a 100 feet distance from the dynamo would be .0156 and with the connexions would total about .017 ohms. Thus, even at this short distance, nearly half the energy would be wasted in the wires.

The reason why incandescent lamps are not so economical as arc lights is probably that the carbon is not in so high a state of incandescence, for with a lamp, the higher the state of incandescence of the carbon, the greater is the proportion of energy usefully turned into light, and hence the greater the economy of the lamp. At present the tendency is to increase the resistance of the incandescent lamps as much as possible, to obviate the difficulties I have indicated. And the most economical arrangement of conducting wires is to have the trunks as large as possible and gradually to taper them off like branches and boughs and twigs on a tree, so that the area of any conductor in all parts of the system shall always be as nearly as possible proportional to the current passing along it.

If it is found impossible to bring the dynamo near its work, and the conducting wires cannot be made very big, a good plan would be to use a storage battery, which is described further on. For though in this way some current would be wasted, yet a dynamo with a very high E.M.F. could be used to charge the battery. In this way but little would be lost in the wires, though from 20 to 30 per cent. would be lost in the battery.

In order to prevent an undue increase of current from suddenly injuring the lamps and conducting wires, safety plugs or fuzes are, by the rules of the Board of Trade, to be introduced into the circuit of each of the service wires. Small safety fuzes should also be provided to each lamp.

An incandescent lamp usually requires a current of about 1·3 ampères. A current much more than double this amount would probably destroy it. Hence some arrangement has to be contrived to cut off the current when it exceeds (say) three ampères. This is usually done by introducing into the circuit a piece of thin lead wire, which, having a high resistance, becomes hot as the current rises, and melts when it exceeds a certain point. The wire must be of a certain length, or else the heat would be carried off as fast as it was generated. Edison's safety fuzes are generally made about an inch long, and the lead wire for small lamps is about the thickness of ordinary packthread.

Other makers, instead of lead wire, use strips of foil, pasted or gummed to pieces of vulcanised fibre, wood, or cardboard. These should be made rather narrower at the centre to ensure their melting there. Even, however, if the strips were of uniform width, they would go at the centre, because at that point the heat is less readily conducted away than at the sides.

But the disadvantage of these contrivances is that they take an appreciable time to act. Sometimes, if the current does not greatly exceed its limit, they take a minute. It is needless to say that long before this time the mischief would be done. With very large sudden accessions of current they act better. They are, however, difficult to construct, being somewhat uncertain in their action.

The safety plugs for the service lines of houses would, of course, require to take large currents, as from thirty to fifty ampères. A piece of tin foil nearly an inch wide would be required for such currents as these, but the resistance would depend on its thickness, whether it was exposed on both sides to the air, the material with which it was fastened down, &c., &c.

CHAPTER V.

ON ELECTRO-MOTORS.

INASMUCH as the Electric Lighting Act of 1882 expressly prohibits the undertakers from prescribing to consumers of electricity the use to which they shall put it, it is probable that it will be largely used for giving motion to machinery as well as for lighting.

Suppose that we take an ordinary dynamo, say a Gramme (see page 209), and suppose that instead of causing the ring to move and thus generate a current through the brushes, we were to send a current through the brushes. The effect of this would be to magnetise the ring in the manner shown in Fig. 31. Page 211. But the result of this would be to cause the portions, P, Q, which were so magnetised, to be respectively attracted to and repelled from N. and S. That is to say, the portion P would be attracted towards N., and Q to S. The ring would consequently begin to move in a direction the reverse of the arrow. But as fast as it moved, the different portions of the ring, as they successively came opposite P and Q, would be successively magnetised. Hence, therefore, continually fresh parts of the ring would always be constantly coming into play and constant motion would take place. And for the same reason as before, the most advantageous position for the brushes would be with a forward lead in the direction of the motion. For the points against which the brushes press would not (as before) be the neutral points, but would be the points of maximum resultant magnetisation.

In other words, if a dynamo, when a motion in a certain direction is imparted to it, yields a current of electricity in a certain direction, then an electrical current sent through it in a reverse direction, will produce motion in the same direction as before. All dynamos can therefore be used, as electro-motors as well as moto-electric machines.

These motors can be made very small. One about three inches long by two inches in diameter would drive a sewing machine (which requires about $\frac{1}{30}$th of a horse-power).

Sir William Armstrong has used electric motors for ploughing, but the most interesting experiments that have been made are those of Dr. Siemens, who has practically constructed electric tramways.

The most important of these are the Lichterfelde line, near Berlin; two lines near Charlottenburg and Amsterdam; one at the Electrical Exhibition at Paris; and the Railway near the Giant's Causeway, in Ireland.

Of these the last is by far the largest. It is six miles long, and has some gradients so steep as $\frac{1}{30}$. The line of rails is single, with four intermediate passing places. The electricity is conveyed along the line by a bar of T-iron, raised about 18 in. above the ground. The car runs on rails, and has steel spring-switches, which press on the bar and take off the current.

The path for the return current consists of the rails on which the car runs. The total resistance of the rails and the conducting bar together is about a quarter of an ohm per mile of the railway. The bar which conveys the current is placed at one side of the rails, like a low fence, supported on wood posts capped with insulite.

The electricity is supplied by a Siemens' dynamo, driven by an agricultural engine at an E.M.F. of 225 volts.

Each tram-car weighs about 52 cwt., and requires a current of about 12½ ampères to drive it, which at an E.M.F. of 225 volts represents 2812.5 volt-ampères, or about four horse-power. At this rate it can draw about six tons over the line, up and down the hills, at a pace over the legal rate for tramways, viz., ten miles an hour.

Mr. Alexander Siemens, and Mr. E. Hopkinson, from whose lecture on the subject (at the Society of Arts, April 11th, 1883) this account is taken, consider the electrical tram-car cheaper than steam, especially as they propose in future to utilise water-power, which is to be had in abundance.

There can be no doubt that a large demand will arise for electricity, as a source of power, for use by jewellers, turners, smiths, hairdressers, and various trades. For nothing will be easier than to have a small electro-motor and simply turn it on and off, without the trouble and noise and dirt attendant on steam and gas engines.

Just, however, as there is a rivalry in light-giving between gas and electricity, so is there also a rivalry in supplying cheap and small motors. The cost of gas engines will be very small, not perhaps exceeding 1d. to 2d. per horse-power an hour, inclusive of all expenses, even if the best gas is used, and it is doubtful whether electricity could be supplied so cheap as this. In the Chelsea Provisional Order it is proposed to charge 70s. per 100,000 volt-ampère hours, that is at the rate of about 5d. per horse-power per hour; a rate greatly in excess of the cost of power supplied by a gas engine.

CHAPTER VI.

ON ELECTRIC METERS.

THE Electric Lighting Act of 1882 provides for the use of electricity by consumers for all purposes to which they choose to put it, and for the use of such lamps as they select. This will necessitate the employment of electric meters to measure the electricity supplied. I now proceed to describe what has as yet been done in this direction. Page 29.

In the first place, we must distinguish between indicators which indicate the state of things at any one time, and meters which keep and add up a continuous record. It is obvious that the former will be of no use as meters, and of no use in enabling an electric company to charge a private person for the electricity supplied to him.

Of indicators there are a great number. It has been said that the *strength* of a current of electricity is dependent on an *electromotive force* driving a certain *quantity* of electricity per second through a conducting wire, and that the *power* of the current for doing work or giving light is dependent on the *electromotive force* multiplied into the *strength of the current*; and the units are so taken, that an electromotive force of one *volt* will drive one *coulomb* of electricity per second through a wire of one *ohm* resistance, thereby producing a current of one *ampère*, with a work-doing power of one *volt-ampère* or "*watt.*" Now, here we find no less than four things to measure,—the volt, the coulomb, the ampère, and the volt-ampère or watt; but these are all interdependent one upon another. The measure of these is accomplished by voltameters, galvanometers, or ampère-indicators or ammeters, and energy indicators.

The word "meter" is used most loosely. Thus, Ayrton and Perry call an instrument an "ammeter" which is no *meter* at all. it is really an ampère indicator. So again, the dynamometer of

Siemens is really an indicator. I do not propose to devote much space to these indicators, as they are chiefly used in electric lighting for testing the instruments and machinery. In the course of my observations I shall, however, just notice those principally in use.

SEC. 1.—*Chemical Deposition Meters.*

It is an experimental fact that if a current be passed through a conducting liquid lying between two metal plates, the metal is dissolved off from one plate and deposited on the other, and the weight of the metal so deposited is an exact measure of the current. This has been adapted by Edison to form a current-meter. The arrangement is placed in a cast-iron box, 12 × 6 × 6 inches in size, the interior of which is represented in Fig. 64.

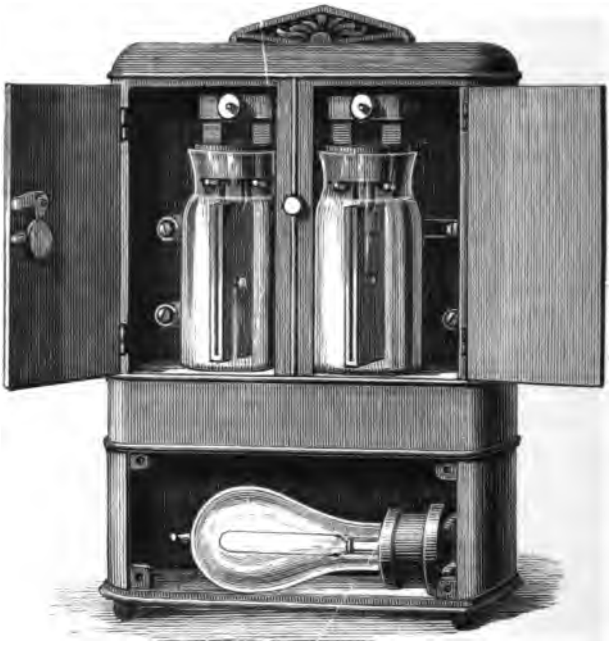

FIG. 64.

The glass bottles each contain two plates of zinc, and a shunt from the current is sent through them both. One is called the "monthly cell," and is so arranged as to indicate the amount of current used in a month; the other is weaker, and indicates a three months' supply. The cells are charged with a mixture of ninety parts of sulphate of zinc dissolved in one hundred parts of pure water. As the shunt, consisting of say half per cent. of the current, goes through the cell, the deposition goes on, and by weighing the plates every month and every quarter the total *quantity* of electricity that passes is measured, one cell serving as a check upon the other. The arrangement is such that each coulomb of electricity used by the consumer is represented in the monthly cell by a deposition of ·0003711 milligrammes of zinc. Thus, if twenty-five twenty-candle Swan lamps were used for a month say four hours per diem, the total number of coulombs would be about: 25 (lamps) × 1.3 (ampères per lamp) × 30 (days) × 4 (hours per diem) × 60 (minutes) × 60 (seconds) = 14,040,000 coulombs, which would be represented by 14,040,000 × .0003711 = 5210 milligrammes of zinc = 80.2340 grains English. If the electricity were at fifty volts, and were sold at the price proposed by most of the provisional orders, viz., at 70*s.* per 100,000 volt-ampère hours, this would cost 6*l.* 16*s.* 6*d.* per month, that is, at the rate of about 1*s.* 8½*d.* per grain of deposited zinc shown by the meter. This would be, light for light, about double the price of gas. It is obvious that very careful handling and weighing is requisite, for a piece of zinc the size of a common pin weighs about two grains, and would hence be charged to the consumer at about 3*s.* In England it is alleged by some that these machines do not act very well. This is owing to the fact that the metal is not practically deposited in exact proportion to the current. Whether this is due to the inequality of the metal causing local currents, or to some other cause, it is difficult to say.

Mr. Edison also invented a sort of oscillating balance, for causing the increased weight of the plates upon which metal has been deposited, to tilt the plate and reverse the current, so as to move a clockwork dial. The lamp shown under the cells in Fig. 64, is arranged so that when the temperature falls below 42° Fahr. it is lighted by the current, and the cells are thus prevented from freezing in cold weather (at an expense which appears to be about .2d. per hour). Modifications of this kind of meter have also been devised by Sprague, Brewer, Jensen, and others.

SEC. 2.—*Mechanical Meters.*

It is a mathematical principle, that if two bodies act each upon the other, the combined effect of their actions is measured by multiplying them together. Thus, if a magnet A with a force

a act on another magnet B, having a force b, the attraction between A and $B = a \times b$. It is also an experimental fact that a coil of wire, round which a current is passing, attracts iron, or magnets, or other coils through which currents are passing, with a force varying directly as the current. A coil with a current c passing through it, will therefore attract a magnetic needle of force f placed some short distance from it with a force $= c \times f$. Therefore if the magnetisation of the needle remains constant the force attracting it varies directly as the current. But if the coil act on another coil through which a current C^1 is passing, then the attractive force between the coils will $= C \times C^1$, and if the same current be running through them both, the attractive force will be $C \times C = C^2$. Or again, if C^1 is a shunt from C, and hence in some regular proportion to it; as for example, if $C^1 = \frac{1}{m}$ of C, then the attractive force between the coils will be $= C \times \frac{1}{m} C = \frac{1}{m} C^2$. And further, if an electro-magnet placed in a coil, be brought near a mass of soft iron, the iron will be magnetised with a force F^1 proportional to the magnetisation F of the electro-magnet. But the force F of the electro-magnet is proportional to the current. Hence, F^1 the force of the induced magnetism in the iron is also proportional to the current, and therefore in this case also we have the attractive force proportional to C^2. Or again, if a coil of wire is brought so near a piece of iron as to magnetise it, again the attractive force between them will vary as the square of the current.

In the first instance, when a permanent magnetised steel needle is placed at a short distance from a coil, the magnetisation of the needle is so great as compared with the feeble magnetisation of the steel produced by the current in the coil, that for all practical purposes it may be neglected, and this is the reason why a magnetised needle is attracted with a force depending on its constant force × strength of current, whereas a piece of iron would be attracted with a force varying as the square of the current. But the magnetic needle must not be placed too near a powerful coil, or this proportion would be no longer true.

The effect of the attraction of a coil upon a magnetised needle is made use of in the common galvanometer.

This consists of a coil or coils of wire with a delicately suspended magnetised steel needle placed in the centre. When no current is passing round the coils the needle sets itself as all magnetised needles will (north and south) in the magnetic meridian. For convenience a small magnet may be placed near it so as artificially to alter its position if required, and bring it to the exact zero on a graduated card. The coil of wires is then turned round, so that the direction of the horizontal portion of the wires is parallel to the direction of the needle, and the needle is then allowed to come to rest, Fig. 64. Now, if a current be sent through the wires it will cut the lines of force of the needle at various points, and tend to turn the needle round at right angles to the direction of the current. The reason of this is not perfectly known, the fact was discovered by Oersted in 1819. The needle will thus be under two influences, one dependent on the earth's magnetism, which is tolerably uniform from day to day, and tending to keep it pointing to the magnetic north, and in the direction of the coils; the other dependent on the current passing through the wires, and tending to turn it so as to lie east and west, that is at right angles to the direction of the wire of the coils. The result will be that the needle will obey both of these forces, so as to take up a position intermediate between north and south, and east and west; and this position will be dependent on the strength of the current and number of turns of wire in the coil, as compared with the magnetic force of the earth. A single turn of wire in the coil will produce the effect, if the current be powerful. If the current be feeble, then many turns are required, the effect increasing proportionately to the number of turns in the coil.

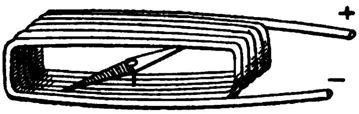

FIG. 65.

We can thus measure the strength of currents by observing the deflections produced by them in a given galvanometer. Sometimes the instrument is arranged so that the currents vary as the "tangents" of the angles of deflection; somtimes as the "sines" of the angles of deflection; sometimes as the angles of deflection themselves. These, however, are mathematical considerations with which at present we have nothing to do. In Sir W. Thompson's reflecting galvanometer, a delicate mirror attached to the needle deflects a beam of light, which appears as a spot upon a scale. Sir William Thompson has also invented a galvanometer of peculiar construction with a large semicircular permanent steel magnet as a constant for comparison. Messrs. Ayrton and Perry have invented a very small instrument on a somewhat similar principle, called an ammeter, which is fairly accurate, and largely in use on account of its convenience and small size. In this machine a small piece of iron or steel is so arranged as respects position and size, that its angular displacement under the action of a current is approximately proportional to the current strength. This arrangement is due partly to calculation and partly to experiment. The instrument of Marcel Deprez is almost identical with that of Ayrton and Perry.

An exceedingly useful instrument is Siemens' dynamometer. It is well known that the force necessary to twist a spiral spring through any angle is approximately proportional to the amount of that angle. A current of electricity passing along a wire attracts any wire parallel to it along which a current is also passing in the same direction, with a force proportional to the two currents multiplied together. If, therefore, a long loop of wire be suspended from a spiral spring, in such a position as to be at right angles to a fixed coil of wire of the same size, and a current be sent through both the coil and loop in succession, the loop will *tend* to turn about its axis, and set itself parallel to the coil. But this turning motion is resisted by the torsion of the spiral spring, and the amount of the torsion of the spring necessary just to prevent the twisting motion, and keep the moveable coil in its initial position, is therefore a measure of the current multiplied by itself, that is of the square of the current strength. Here we have no comparison with the magnetism of the earth, or with permanent magnets, which may change their condition; the measure of the current is obtained by comparing the attractive force of the current with the resisting force of a spiral spring. One defect of the instrument is that with very feeble deflexions the torsion of the spring through small angles is somewhat uncertain. It is also much affected by the proximity of magnets and its period of coming to rest is slow,

Volt-meters differ but little from galvanometers. This is in consequence of Ohm's law. For

$$\text{Current strength through any wire} = \frac{\text{electromotive force at terminals}}{\text{resistance of wire}}$$

Hence, then, if we place a fine wire as a shunt to any circuit a certain current will be abstracted, proportional in strength to the electromotive force between the points where the shunt is joined to the circuit. This shunt must be so long and fine as not appreciably to affect the rest of the circuit. The current passing through the shunt can then be measured by a galvanometer, and is a measure of the electromotive force. It is true that this method makes the currents very feeble indeed, but this can be got over by using very sensitive and delicate instruments. This is attained by winding the galvanometer with exceedingly long and thin wires of a resistance of several thousand ohms, round which the current is sent. These serve at once to introduce the necessary resistance, and also by reason of the multitude of turns, to make the instrument delicate.

In general it may be said that if we have two terminals of any machine or battery, through which a current is passing, that the current strength must be measured by means of a thick wire galvanometer placed in the circuit. If we know the total resistance of the circuit we can then compute the electromotive force by means of the formula $C = \frac{E}{r}$, that is, $E = C\,r$. But if we do not know the resistance of the circuit, we must then use a very delicate galvanometer with fine wire, and shunt a very feeble current through it from the terminals of the machine. The feeble current thus obtained will then be a measure of the electromotive force. If a thick coil placed in the main circuit be made to attract a thin coil shunted from the main circuit, then the attractive force of the first coil depends on the main current. But the attractive force of the second coil depends on the feeble shunted current, which, as we have seen, is proportional very nearly to the electromotive force, or E. These coils will therefore attract one another with a force proportional to $C \times E$. But $C \times E$ measures the *power* of the current. So here we have the foundation of *energy* indicators or meters. **Page 174.**

Boys' Energy Meter.

This meter consists (Fig. 66) of a large thick coil A, through which the main current passes, forming a sort of well into which a fine shunt-wound coil B of high resistance dips, like a bucket into a well. The bucket-coil is suspended from a beam C, mounted on an axis like that of a beam-engine, and counterpoised by weights D D^1, in such a manner that when no current is passing through the coil, the beam naturally tends to come to rest in a horizontal position. The weights are so arranged, that if a current acts through the coil, then its attractive force, that is to say, C × E, will draw the end of the beam down to an amount such that the tangent of the angle of inclination of the beam is a measure of the C × E, that is, the energy of the current at any time. These tangents are integrated on a principle which has been invented by Mr. Boys, and by him applied to various instruments. The beam carries a small wheel pressing against a cylinder, E F, whose axis is horizontal. When the beam is horizontal the plane of the small wheel is also horizontal. If, when in this condition, the cylinder is made to move slowly along its axis, G H, the wheel will roll over its surface in a straight line along the cylinder surface parallel to the cylinder axis. But if, by reason of an attraction from a current, the bucket dips into the well, then the beam and tangent wheel are deflected, and as the cylinder moves it is caused to rotate, as shown by the arrows. And the amount of rotation can be mathematically shown to be precisely proportional to the time integral of all the tangents of the angles. The number of rotations of the cylinder in a given time is thus a measure of the energy of the current which has passed during that time. I have tried experiments with this instrument, and it appears to be absolutely correct. There are no broken contacts and no

Page 263.

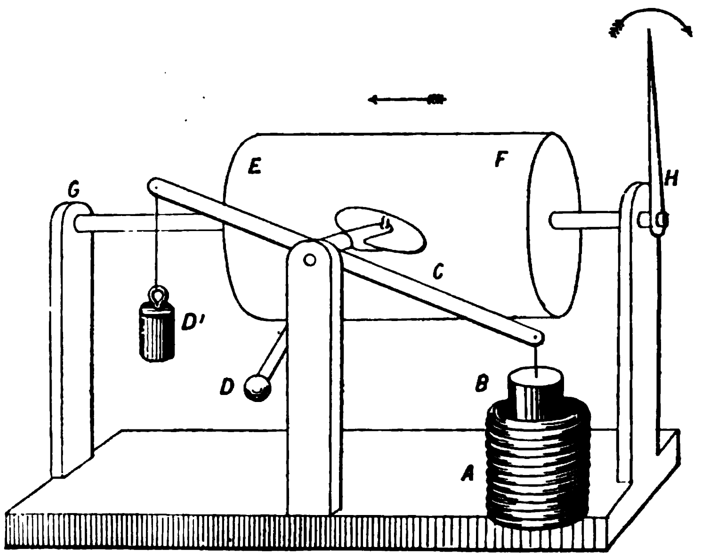

Fig. 66.

sparking, nor any waste of current, neither is there any limit to the range with which the instrument may be constructed. It also is of such a nature that the most delicate current can be measured by it, down to a fraction of an ampère. The instrument which has been at present constructed measures currents with a range of energy from 0 to about 1000 volt-ampères. It requires winding up like a clock once a month, or at stated intervals. This is not altogether a disadvantage, as the meter must be periodically inspected to take the readings; and even were this not so, the consumer could easily be provided with a key without being able to open the body of the instrument. A simple automatic arrangement would turn off the current if the clock ran down, like the arrangement made in watches to prevent over-winding. If the clock then ran down, the electric current would stop until the consumer wound up the meter again.

However, to prevent this necessity for re-winding, Mr. Boys had no sooner completed this instrument than he set to invent one which should be quite automatic. It is a mechanical fact, that the speed of a clock varies as the square root of the force of gravitation at the place where it is going. Thus, if we took an ordinary pendulum clock which kept good time on the earth, to the moon, where the attractive force is less, the speed would be less than its former amount.

This will not be exactly true of a clock driven by a *spring*, for to be quite true, the driving force should vary with the force drawing down the pendulum, whereas the driving force of a spring is constant.

However, neglecting this source of error, Mr. Boys removed the pendulum of a small clock and placed a small piece of soft iron on the pendulum axle, and surrounded it by an electro-magnet round which the current to be measured circulated. The time of the clock was then found to be approximately proportional to the current. For since the time kept by the clock varied as the square root of the force upon the iron armature which took the place of the pendulum, and as the said force varied as the square of the current, it followed that the time of the clock varied as the current. This instrument worked correctly from one to three ampères, but after that, the error due to its being a spring clock caused it to lose considerably,

To remedy this a new form of driving apparatus has been devised, of which the force is proportional to the attracting force on the pendulum or armature, that is, to the square of the current. Meantime, Mr. Boys devised a different form of his vibrating meter. He removed the clock, and substituted for it a second driving-armature, Fig. 67, with a very ingenious arrangement, whereby the controlling or recording armature had an electrical impulse given to it every now and then to keep it oscillating. This impulse was proportional to the square of the current, and thus made a theoretically perfect instrument. This instrument has also given very good results within its magnetic limits.

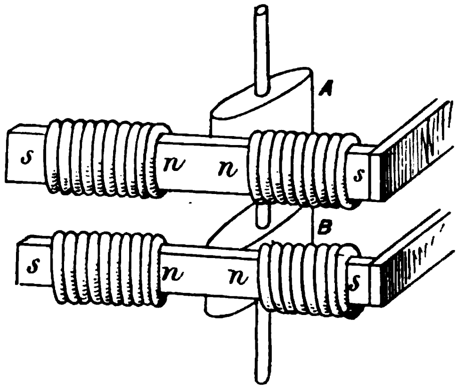

FIG. 67.

For it must be remembered that the laws determining the attractive forces produced by currents in electro-magnets are only true within the limits of the magnetic properties of the iron. A diagram of this meter is given in Fig. 66. A is the impulse armature and B the controlling armature. This particular instrument works well up to twenty-five ampères.

It is termed Boys' Vibrating Meter.

Hopkinson's Current Meter.

The principle of this instrument is as follows:—Let a small electro-motor be provided, and driven by the current to be measured. It will then cause a governor mounted on its shaft to be expanded with a centrifugal force varying as the square of the rapidity of the motor. But this rotary motion would tend to become quicker and quicker. In order to check it, let an armature be placed close to a coil through which the current to be measured is passing, and let this armature and coil be free to approach one another. Now, if the current is sent through the coil, their attractive force will vary as the square of the current. If, then, one of these be rigidly fixed, and the other connected with the governor above mentioned, so as to oppose and balance its centrifugal force, it is evident that the governor will be submitted to two influences, one varying as the square of the speed of the small dynamo, the other varying as the square of the current. As a result these will always balance one another, for if one becomes too strong the governor either rises or falls, and by a simple mechanical arrangement turns off or on the current running through the coils of the dynamo, and thus constantly keeps matters so balanced that the square of the speed of the dynamo is always balanced by and proportional to the square of the current, that is, the speed of dynamo varies with the current, and by means of a train of clock-wheels may be made to measure up the current from time to time. The instrument works up to the limits of the saturation of the iron, and those which are at present being made indicate currents up to 100 ampères.

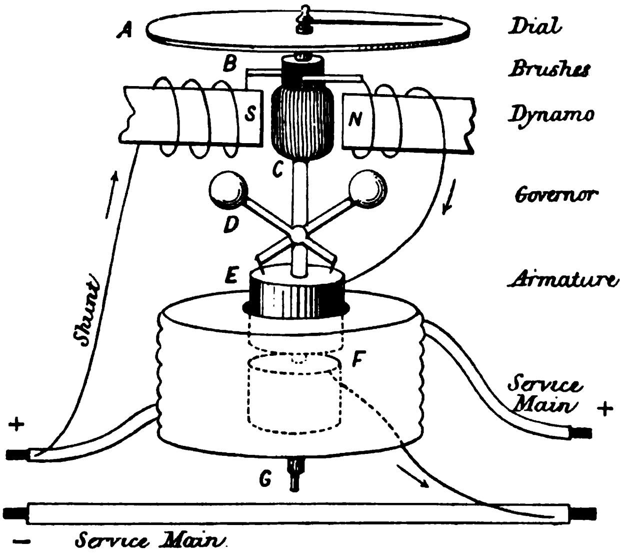

Diagram of Hopkinsons Current Meter:

FIG. 68.

Fig. 67 is a diagram sketch of this machine. SN is the dynamo, with a bobbin on the shaft C G; D is the governor attached to the shaft, and raising the iron armature E, which is balanced on springs. A shunt from the fixed coil round which the current passes works the dynamo. An index finger shows the revolutions of the shaft on a dial A, and has a train of wheelwork attached to it. The shunt which works the dynamo is carried down to the armature E and thence to the armature F, also mounted on the vertical shaft. At rest these are so kept apart by balancing the spring, that no current flows over the interval. Directly a current begins to flow, the armatures E F are dragged together and make contact, this sends a current through the dynamo, which commences to cause the shaft C G to rotate. The acceleration of the magnets causes the dynamo to rotate faster and faster, and consequently the governor balls to fly out more and more. This goes on till at last the armature E is dragged away from F and the current broken; the acceleration of the dynamo is now checked, and checked at such a point that its speed of rotation, as explained before, is a measure of the current strength. In this way it gets an occasional impulse or rather a constant series of small impulses from a repeated series of "shivering" contacts between E and F, which are made to rub one upon another.

Messrs. Ayrton and Perry's Energy Meter.

This meter is made out of what appears to be an ordinary kitchen eight-day clock, by replacing the pendulum bob by a fine coil of wire, carrying a shunt from the current and placing a main coil electro-magnet exactly at the middle position of the pendulum. The force of gravity being represented by g, as soon as the current is turned on, the force on the pendulum becomes increased by an amount depending on the magnetic attraction between the pendulum bob and the main coil magnet. The first of these depends on E, the second on C; therefore the force on the pendulum now becomes $g + \text{C} \times \text{E}$. And hence the rate of going of the clock $(t) = \sqrt{g + \text{C E}}$. But the natural time of the clock (T) when no current is passing is $\sqrt{g}$.

$$\text{Hence } \frac{t}{\text{T}} = \sqrt{1 + \frac{\text{C E}}{g}}.$$

Now, if the shunt of the current is so arranged that C E is very small as compared with g, then $\frac{\text{C E}}{g}$ would be a very small quantity, and therefore the square of half of it would be inappreciable. By an algebraic artifice we may therefore say, that—

$$\frac{t}{\mathrm{T}} \text{ is nearly } = \sqrt{1+\frac{\mathrm{C\,E}}{g}+\frac{(\mathrm{C\,E})^2}{2\,g}}$$

$$= \quad 1+\frac{\mathrm{C\,E}}{2\,g}.$$

That is to say $\frac{t-\mathrm{T}}{\mathrm{T}} \times 2\,g = \mathrm{C\,E}$ (approximately).

But $t-\mathrm{T}$ is the actual gain of the meter clock, and $\frac{t-\mathrm{T}}{\mathrm{T}}$ is the ratio of that gain to the true time.

In other words, the energy expended by the current in a given time is very nearly proportional to the gain of the clock. Hence the consumer of electricity would be charged more money for every minute per diem that his electric-meter-clock gained upon some standard timepiece. His only plan to defeat the electric light company would be by the skilful use of a large magnet close to the clock, to retard the pendulum and make it go slower.

Several other inventions for electric meters have been proposed. One of the earliest was that of Mr. Lane-Fox, who caused a disc to assume a position upon a cone, dependent on the force of the current. Thus, in a manner similar to the action of the well-known double cone speed regulators, the current was measured.

Other proposals, as those of Swan, cause a clock to keep time while the current is passing, and to stop when it ceases; and in some cases separate movements are provided for the separate lamps in the house. Another idea has been to cause a pipe or tube, through which a liquid is running under pressure, to open or close proportionately to the current strength, and thus let more or less liquid through. The quantity of water which flows would thus be a measure of the currents.

CHAPTER VII.

THE COST OF ELECTRIC LIGHTING.

THIS is a very difficult matter to deal with at present. The following are the considerations necessary:—

In the first place, the cost must be compared with the light obtained. It is of no satisfaction or use to any one to see a beautiful light burning brilliantly in some elegantly fitted show-room at an exhibition. What the public want to know is, how much light is being obtained, what electricity is being used to get it, and how much that electricity costs to produce.

The parliamentary standard at present in use for gas is the standard candle; that is, a candle of such size and make that it burns 120 grains of pure spermaceti wax per hour. See 34 & 35 Vict., ch. 41, schedule A, part II. These candles are made by various makers; they are about 5-6ths of an inch in diameter. A little wax is mixed with the spermaceti to give it consistency, and the candles should be kept some time before use. With care such candles can be made to burn true to about three or four grains per cent. But, unfortunately, the quality of the wax varies, the wick is liable to bend and turn about, and as a practical fact I believe that a standard candle is liable to errors in light-giving, even under favourable conditions, of at least ten per cent. On this account gas or oil photometers are much preferred.

The comparison of light is made upon the principle pointed out in Fig. 3. The two lights are enclosed in black boxes, so that no reflections take place, and moved about till they are seen to illuminate a disc of paper exactly to the same extent. Several ingenious mechanical devices exist for making this comparison easy to the eye. The ratio of the light-giving powers of the lights then varies as the square of their respective distances from the disc. Page 162.

In general five cubic feet of good gas, burnt in a new well constructed burner, are estimated to afford a light of sixteen candles. As the burners get old, however, their efficiency is much impaired. As a general rule, the larger the burner, the greater light it gives in proportion to the gas consumed. At 3s. per thousand cubic feet it is easy to see that such a sixteen-candle gas light costs $\frac{5}{1000} \times 36\text{d.} = .18\text{d.}$ per hour; that is to say, .0112d. per candle power per hour.

As has been said before, the arc lamp is about three or four times more efficient in point of light-giving than the incandescent light. For each 100 volt-ampères of current a light of about 140 candles could be got from an arc light, whereas only about thirty candles can be got from an incandescent lamp.

The problem is now reduced to the inquiry how much a current costs per volt-ampère per hour. This will be solved by inquiring (1) what is the prime cost of the machinery, dynamos, engines, sheds, buildings, &c.; (2) what does it cost to work them and (3) what is their efficiency. A horse-power of work is taken at 33,000 foot-pounds per minute, that is to say, an engine exerting one horse-power would raise 33,000 lbs. to the height of one foot during every minute it was employed. The *theoretic* value of this in volt-ampères has been calculated, and it is found that the horse-power, if it could be completely utilized, would give a current with an energy of 746 volt-ampères, enough therefore *in theory* to give us about 900 candles arc light or 224 candles of incandescent light. But this result can never be practically got. And, what with loss in the dynamo, and friction in the cylinders, shafts and belting, we are fortunate if for each horse-power of work done in the engine cylinder; we get 550-600 volt-ampères. That is to say, each indicated horse-power of work (for the indications are always taken at the engine cylinder) will yield 700 candles of arc light or 165 candles of incandescent light. The question now is, what is the cost per horse-power of working a dynamo? The result of experience certainly shows, that the larger the installation the better will be the result. As a mean I believe it will be generally admitted that the cost of a large complete installation of engines, sheds, dynamos, and all mains, wires, &c., external to the houses, and not counting interior fittings, will be about 20*l.* for the steam gear, and 20*l.* for the electrical = 40*l.* for every horse-power employed, or (as an example) 50,000*l.* for an installation sufficient to light 10,000 twenty-candle lamps.

The next question is, how long the lights will be used daily. Careful inquiry seems to establish the fact that the average daily user of the lamps through the year, one day with another, will be about four hours a day, or (say) 1500 hours per annum. For large engines we should find that the annual cost of working per horse-power per annum is about as follows:—

	Annual Cost per Horse-power.	
	£	s.
For coal, at 21s. per ton	2	0
For wages, oil, waste, stores	1	0
Repairs to engines	2	0
,, dynamos	2	0
Management, superintendence, &c.	1	5
Five per cent interest on cost of dynamos (£20) ...	1	0
,, ,, ,, engines (£20) ...	1	0
Ten per cent profit on capital outlay = Ten per cent of £40...	4	0
	£14	5

This gives us a total of 14*l.* 5s. per annum for 1500 hours of such a light as one horse-power will yield. If we are using incandescent light, of which one horse-power will yield 165 candle-power per hour, we shall thus get a light of 165 candles for 1500 hours at a price of 14*l.* 5s.; that is to say, .0138d. per candle power per hour; a result rather more than the figure above mentioned (·0112d.) of gas at 3s. per thousand. To attain this result, however, the electrical machinery must be very economically worked, and the area must be very compact. For though I think the above figures are fair, they are none too large. And it will easily be seen that they do not leave a very large profit for companies. They are rather calculated on the assumption that the lighting is to be done by local authorities that do not look to make a profit out of the business. The cost of electricity on the above assumption, taking 565 volt-ampères as the yield of a horse-power, will be $\frac{14l.\ 5s.}{1500 \times 565}$ per volt-ampère per hour; or, if 100,000 volt-ampère hours is taken as the unit, it will cost 34s. In most of the Provisional Orders hitherto sent in to the Board of Trade, 70s. is named as the undertakers' maximum charge. This is double my figure, and reckoning as before that 100 volt-ampères will give a light of thirty candles, the cost per candle power per hour would be ·0285d., or about 2½ times the price of gas at 3s. a thousand, and double the cost I have estimated for electricity.

As has been said, these prices are for electricity at the door of the consumer. The price of "gasaliers" and "electroliers" and internal fittings will be about the same. But it must be remembered that incandescent lamps cost at present about 5s. a piece, and only last about 1200 hours. This, then, involves an additional cost of ·05d. per hour per lamp, or if we are using twenty-candle lamps, we must add ·0025d. per candle power per hour. It is, therefore, clear that as the price of large and small lamps is the same, greater economy will be got by using large lamps, which also give a better light in proportion to the energy used to light them.

To take an example. Let us suppose a house at present to be lit with gas burners. Let us take an ordinary large London twelve-roomed house, allowing as follows:—Basement, ten lights, ground floor ten, first floor ten, and five each for three other floors, *i.e.*, forty-five sixteen-candle burners. Total, 720 candles for 1500 hours per annum. This would require 337,500 cubic feet of gas per annum, which, at 3s. per thousand, would equal about 50*l.* 10s. Now replace them by electricity. It was calculated above that 165 candles, the yield of one-horse power, for 1500 hours would cost 14*l.* 5s. per annum. 720 candles will, therefore, cost 62*l.* The wear of lamps will be five 50-candle lamps, twenty 20-candle lamps, and seven 10-candle lamps; total, thirty-two lamps of total aggregate of 720-candle power, and lasting each, on the average, 1200 hours, at 5s. each. (For the larger lamps cost about the same price as the smaller). This comes to a little under 10*l.* per annum, which gives us 72*l.* per annum as the cost of lighting a house with electricity, as against[*] 50*l.* 10s. for gas, or, say half as much again. For this extra sum we have a pure, clean, healthy light, and in the daytime the energy of the current will, undoubtedly, be used for all domestic work, from driving a sewing machine down to turning a spit. If the electricity be used more than four hours a day, a great reduction in price will at once be possible.

The items in the above calculation that are open to most question are those for repairs to dynamos and cost of management. The question of repairs is still an open one. If the undertakers are bullied by telegraph authorities, road authorities, and gas authorities, plundered by private interests, and harassed by vexatious summonses before magistrates—of course the management expenses will be very great—and for a considerable time the employment of highly-paid inspectors and a trained staff will be needful. The above figures are therefore rather figures of the future than of the present. At the same time there are so many persons of great wealth in a large town like London that I believe very many will be willing to pay such a price for electricity—at all events for use in their *salons*—that electric lighting will come into use. And there can be no doubt whatever that the progress of invention is every day vastly improving and cheapening the electric light.

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[*] If such a consumer were charged at the rate of 70s. above cited as the maximum undertaker's charge, his bill would be 138*l.* including 10*l.* as before for his lamps, or at 7d. per 1000 volt-ampère hours (as in some provisional orders), it would be 116*l.*

There is, however, another consideration. Gas is now far higher in price than it need be. Most local authorities that supply it make a profit by so doing. The value of the residual products of gas retorts is so great for the naphtha, paraffine, creosote, pitch, aniline, and other chemicals they afford, that gas would have to be made, even though it were only used for heating the dynamo engines. Therefore as electricity comes in, the price of its rival gas will steadily fall, and gas will almost always be able to undersell electricity.

The use of gas it seems will therefore continue, at all events of a cheaper and commoner nature, for heating purposes.

In the above calculations gas has been estimated at 3s. per thousand. But it must be remembered that in some places it is far higher, as New York at 10s., and Paris at 6s. In Newcastle, on the other hand, I believe it is 1s. 9d., and in fact in Newcastle coal costs about 6s. per ton, while the residual gas products fetch over 7s. The gas is really almost made for nothing.

With arc lights, as has been seen, nearly 4½ times the light per horse-power is got, as is obtained from incandescent lights. But the arc light is not popular, it flickers, and is of an uncertain character, as may be seen at the South Kensington Museum, where the arc light is shed upon the pictures. Moreover, it cannot easily be made of small size for rooms.

If incandescent lamps could only be utilised with more energy they would be quite as economical as arc lights. Thus an ordinary Maxim 50-candle lamp can be raised even to 600-candle power. In this state it is nearly as economical as regards consumption of energy as an arc light, but unfortunately at this rate it would be speedily destroyed.

CHAPTER VIII.

STORAGE OF ELECTRICITY BY MEANS OF ACCUMULATORS.

By the storage of electricity, is meant the arrangement of metallic plates in an acid in such a manner that when a current of electricity is passed into them they are gradually converted into the positive and negative plates of a battery; so that, when the charging process is over, the plates, on being united by a wire, give back the current they had obtained. In this process they are reconverted into their original state, after which they may again and again be charged and discharged.

The material of which these storage batteries are made is in general plates of lead immersed in dilute sulphuric acid. The nature of the chemical changes which take place is still a matter of dispute, but the general effect of a charge of electricity is to oxygenate one plate more than the other, and of a discharge to restore things to their previous condition. In fact, the storage battery is after all only an extension of the oxygen and hydrogen battery of Mr. Justice Grove, and of the process called electrolysis.

The principal kinds of storage battery at present in use in England are those made by the Electrical Power Storage Company, and those of M. de Kabath. Of the former that generally preferred is the Faure-Sellon-Volckmar accumulator, so called from the various persons who have a share in the merit of its invention.

The mode of manufacture is this:—Lead gratings, about 6 x 8 inches or larger, are filled with red lead slightly moistened with acidulated water to the consistency of clay. Similar gratings are also filled with yellow litharge. These are then dried. Eight of each of these are then placed in a cell alternately, and are united up in compound circuit, that is, the red lead plates are all united together, and the litharge plates together, being separated by pieces of india-rubber so as to keep them about one-fourth of an inch apart. The cell is then filled with dilute sulphuric acid in the proportion of one of acid to about two of water.

The current from a powerful dynamo is then introduced. In a few hours both plates become of a dark grey colour. They are now removed from these plates and dried, and can be kept a considerable time. If kept too long, they would be weakened by a film of oxide forming on their surface, which could be removed either by scraping, or, better still, by passing a current through them again for a few minutes.

When required for use, they are again placed in sulphuric acid and water; the moment contact is made between their terminals, a current will pass. Each box serves thus as a cell, with some three square feet of surface, and from the nature of the materials the electromotive force is about 2 to 2½ volts, that is to say, rather greater than the most powerful voltaic cell, such as Grove's or Bunsen's. A box about a cubic foot in size is said to contain about two horse-power-hours stored up. The larger boxes are about double this size, and will afford a current of about 800 ampères for one hour, or less for a proportionally longer period, the E.M.F. of each cell being two volts. About 25 to 30 cells worked with a No. 2 brush machine, driven by a one horse-power steam, hot air, or gas-engine, will work twenty-four incandescent lamps of twenty-candle power during the time light is usually required in offices. They require an occasional cleaning, and are said to last, with daily use, for several years; but this is the result, I should imagine, of conjecture. It is, at all events, certain that the plates can be charged and exhausted over and over again, and that up to a certain point they improve by use.

These accumulators, when charged with electricity, can be discharged at any rate that is desired. They contain so many volt-coulombs of electricity stored up, and by varying the resistance can be made to give any desired current—a small one for a long time, or a large current for a short time. As a rule, a battery that takes twelve hours to charge, ought to be so discharged as to take about eight hours to discharge, and will yield about 80 or 85 per cent. of what is put into it, though it is stated that even higher percentages have been obtained, under favourable conditions. Only a continuous current dynamo can be used to charge the accumulators.

KABATH'S ACCUMULATORS.

The system of N. de Kabath is also a good one. A number of plates of lead are placed in an earthenware cell. Half of them are united together to form one pole; the other, placed alternately with the former, to form the other pole. These plates are not solid, but consist of a large number of strips of lead built up and held together by suitable lead bindings, so as to present a large surface; the cell is then filled with a mixture of one-fifth part of sulphuric acid to four-fifths water. As soon as a current is sent through the cell, peroxide of lead is formed on the plates in connexion with the positive pole. When the cell is fully charged, it gives a current with an E.M.F. of about two volts. Its resistance is very small, owing to the enormous surface of lead exposed. When first charged and discharged the cell polarizes very rapidly, and requires a preparation of at least 60 to 80 preliminary charges and discharges, and improves by constant use. It practically returns 75 to 80 per cent. of the electricity sent into it.

These cells are only an improvement and modification of those of M. Planté. They seem to work very well in use.

Opinions seem very divided as to the true return obtained from accumulators. Some persons place them at eighty per cent., and some as low as fifty. The true figure probably depends on the care with which the storage battery is used, and in the hands of ordinary persons the percentage would probably be between the above figures.

CHAPTER IX.

GAULARD AND GIBBS' INDUCTION COILS.

It was pointed out in the chapter on Conductors that the capacity of a wire to carry a current depends on the strength of the current, and not on its energy. It was also shown how large wires need be, to prevent the great loss of energy in them, unless the currents conveyed along them are small. From this it clearly results that the most economical manner of distributing electrical energy is by currents of small quantity, but of enormous electromotive force. For if once the currents are large in quantity, then the wires that convey them must also be large, or else there is great loss of power.

In order to effect this economy, Mr. Gaulard proposes to use currents of enormous electromotive force, say of 100,000 volts, but of small quantity, say fifteen ampères. The energy of such a current would be 1½ million watts, or over 2000 horse-power, enough for 20,000 incandescent lamps, yet this current would go easily along an ordinary wire not more than a third of an inch in diameter. A current of equal energy, but of the usual E.M.F., say 100 volts, would have a current strength of 15,000 ampères, and require by the Board of Trade regulations to be nearly 4½ in. in diameter, or about 150 times as big, or else it would be heated and spoiled. Moreover, for reasons that are explained in the chapter on Conductors, even with this big wire it would be almost impossible to supply lamps in parallel arc at a distance of over half a mile without a loss of about half the total energy wasted in heating the wires, whereas in the first case there would be very little waste.

The difficulty, however, is how to convert these currents of such high E.M.F. into currents for use in every-day life. For even 800 volts is most dangerous, and over 200 is forbidden by the Board of Trade. A contact, therefore, even for an instant, with such currents would be immediately fatal. Messrs. Gaulard and Gibbs propose as a solution the use of large induction coils. In order, however, to understand the principle of these, we must return to the explanations given at pages 179 and 182.

On page 182 it is stated that if a ring of metal be caused to approach a magnetic pole so that the lines of force passing through it are diminished or increased, during the time of such increase or diminution a current is made to traverse the ring. It was also assumed (page 164) as part of the lines-of-force theory, that the strength of a magnetic field could be represented by the number of lines of force supposed to traverse it. Hence, then, it is not the *mere motion* of the ring that causes the current, but the variation of intensity of the magnetic field in which the ring is placed. We may vary this strength of field by moving the ring or the magnet, but may it not also be varied by altering the strength of the magnet? This question, which seems dictated by theory, is answered in the affirmative by experiment, and it is found that if a coil of wire be placed near a magnet, so that the lines of the magnetic field pass through it, that every variation of the magnetic strength instantly induces a current in the coil. It would, of course, be difficult to vary the strength of a permanent steel magnet, but if for a permanent magnet we substitute an electro-magnet, then it is easy to see that every variation in the current flowing round the coils of the electro-magnet will cause a corresponding current to flow in the coil placed near it.

And it is also easy to see that if the current in the electro-magnet is increased, more lines of force are caused to pass through the coil, and the effect is as if the coil were brought nearer the magnet. A consideration of Figures 8 and 11 will show that in every case this will cause a current to flow through the coil in a direction the reverse of the increasing current round the electro-magnet, and, on the other hand, any current ceasing to pass round the electro-magnet, or diminishing in strength, will cause a current to pass in the coil in a direction the same as the direction of that of the ceasing or diminishing current.

This principle is utilized by winding a bar of iron with a wire called the primary wire, along which the inducing current is to pass.

Above this, the secondary wire is wound, in which the current is to be induced.

By a suitable contrivance the primary current is now broken and remade very rapidly, and at each make and break an instantaneous current is produced in the secondary wire. In this manner an intermittent or alternating current can be exchanged for another alternating one.

But little seems to have been gained as yet; for the transformation of energy always involves waste, and, indeed, this operation would be of no use if the alternating current so obtained were exactly of the same nature as the primary current. It would only be like exchanging a given current for a slightly inferior copy. This, however, is not the case.

For though the energy transmuted remains the same, it is yet in our power by making the primary and secondary coils of different lengths and thicknesses to transmute the current strength and electromotive force. Thus, if in the primary wire we have a current of high E.M.F. and low current strength, we can exchange it for one of low E.M.F. and great current strength, and *vice versâ*.

This, then, is the solution of the problem, provided only the waste of transmutation is not too considerable.

Small induction coils have long been made on this principle, the primary wire is short and thick, the secondary wire is long and thin, hence a low E.M.F. and large current strength is converted into a high E.M.F. and small current strength, and the effects from the secondary coil almost resemble those obtained from electricity in a static condition. (See page 170.)

The machines of Messrs. Gaulard and Gibbs are merely very large induction coils.

In the most recent patterns, the secondary wires completely surround the primary wires, thus diminishing their self-induction. These secondary wires are so arranged that they can be united up either in series or for tension; so that arc and incandescent lamps can be fed at the same time.

Experiments have been made to determine the loss of power on this system, and it has been found to vary from thirteen to twenty per cent. But the machine is still capable of great improvement, and it is expected the loss will soon be reduced to ten per cent.

This invention, simple as it is, opens a vast field to new adaptations. For it is by no means certain that electricity could not be generated by frictional induction machines such as those of Holtz, or Windhorst, and then transmuted into alternating currents of low E.M.F. suitable for ordinary use.

There is, however, a great disadvantage in attempting to convey alternating currents to a distance. For if a rapidly alternating current is sent into a cable of great length and capacity, then, before each charge can get fairly from one end to the other, a reverse charge is sent into it, and as a result these charges neutralize one another, so that alternating currents cannot conveniently be sent through long distances without greatly lessening their energy. This may prove a serious difficulty; but there is no reason why direct intermittent currents should not be employed.

Electric lighting requires development. Any one who will compare the daguerrotype of thirty years ago, with the splendid autotype permanent photographs at present made, and which are even becoming artistic, will not find it hard to imagine as great a difference between the electric machinery of to-day and the machinery of the future.

APPENDIX.

ON THE NATURE OF ELECTRICAL UNITS OF MEASUREMENT.

IN the previous chapters something has been said respecting the volt-ampère and coulomb. I propose briefly to explain how these units are fixed. When anything is to be *measured*, it must always be by reference to a standard quantity of that thing. Thus, length is measured in feet or metres, time in seconds, areas in square feet or metres, volume in gallons, &c.

Mathematicians regard some of these ideas as elementary, or fundamental, and some as derived. Thus, they consider areas as made up by multiplying together two lines at right angles to one another; volume they make up by multiplying an area by a line. Velocity is regarded as space divided by time, and so on. They have thus arrived at three primordial conceptions, viz., length, time, and mass, or quantity of matter (not volume). For the unit of length the centimetre is taken, that is, $\frac{1}{1{,}000{,}000{,}000}$ of the length of a line drawn along a meridian of the earth from the pole to the equator, one centimetre equals .3937 English inches. For the unit of time one second is taken, *i.e.*, $\frac{1}{24 \times 60 \times 60} = \frac{1}{86400}$ of the average time occupied by the earth in turning round upon its axis, with respect to the sun, that is, an average transit of the sun from meridian to meridian. For the unit of mass we take one gramme, or the quantity of matter contained in one cubic centimetre of water at zero centigrade, *i.e.*, at the freezing point of water, equal .002204 lbs. avoirdupois weight.

The notion "mass," or quantity of matter in a body, is an artificial one. The comparison of masses is made by comparing their weights, that is, by comparing the forces which the earth's attraction would exercise on them. For the earth acts upon each element or unit of mass with a certain force. Hence the greater the mass of a body, the greater its weight. Some bodies (as lead) have a large mass in a small volume; others (as cork) have a small mass in a large volume, that is, a small number of units of mass for the earth's force of attraction to act upon. The use of the word gramme as a unit of *mass* must not be confused with its use as a unit of *weight*. A cubic centimetre of water at zero, if taken to the moon's surface, would still be a gramme of water, but it would not be attracted by the moon with the same force as by the earth; hence its weight would have altered.

From these units we build up a system as follows:—Areas are computed in square centimetres; volumes are computed in cubic centimetres; velocities are computed by dividing space passed through by the time taken to do it.

When a force acts on a body it tends to move it, and as the force continues to act on the body the motion is constantly increased. Forces can therefore be measured by their power of producing motion in masses, that is, by the velocity they can engender in a mass in a given time, so that they are measured in terms of mass multiplied by velocity, and divided by the time. But velocity is measured by length divided by time. Therefore forces are measured in terms of mass multiplied by length divided by time squared—an artificial conception, but one which is necessary to express the peculiar properties of force with respect to mass, time, and length. This expression therefore means, that if a force F, acting upon a mass M for a certain time T cause it to move through a certain distance L, then F will vary directly as the mass, directly as the distance, and inversely as the square of the time taken to cause the motion through the distance.

This expression $\frac{M\,L}{T^2}$ is said to be the unit-dimensions of F, and thus the unit-dimensions of any quantity indicate the laws governing it. The unit-dimensions of area is L^2, that is to say, the areas of surfaces vary as the squares of their linear dimensions. L^3 is the unit-dimension of volume, and indicates that volumes of substance vary with the cube of their linear dimensions, and generally we shall find that all units compounded of length, time, and mass, indicate by their form the laws regulating the relationship of the thing in question to length, time, and mass.

Again, the dimensions of the unit must be taken into account, if any of its factors are changed. Thus if we had a force in terms of units $\frac{M\,L}{T^2}$ when L, T, M were the centimetre, second, and gramme (called the C. S. G. system) and we wished to change it into a system in which the yard, the minute, and the pound avoirdupois were the units, then since

1 Centimetre = .0193 yards.
1 Second = .016 minutes.
1 Gramme = .002204 lbs.

we should multiply our old quantity by—

$$\frac{(.0193)\times(.002204)}{(.016)^2}. =.155.$$

The question now arises whether these mechanical conceptions can be so built up or adapted as to be applicable to the electrical units. Electricity cannot be measured in feet, nor has it weight or volume. But it is capable of exerting force. Hence, then, if we so arrange the electrical units that electrical force shall be of the dimensions of mechanical force, we shall have adapted the mechanical system to electricity. But what are these electrical forces? They are of several kinds. Two bodies electrified with static electricity of opposite natures will attract one another. Two magnetic poles of opposite natures attract one another, and two wires or conductors along which currents are flowing in the same direction also attract one another. To all of these attractions we must, therefore, give the dimensions of force, viz., $\frac{M\,L}{T}$.

Let us take these in order. The static electrical force between two quantities Q Q′ of electricity at a distance L apart is $\frac{Q\times Q'}{L^2}$ And this is to have the dimensions $\frac{M\,L}{T^2}$, that is to say $Q\times Q'$ is to have the dimensions $\frac{M\,L^3}{T^2}$, but $Q \times Q'$ are of the same natures, hence the dimensions of Q are $M^{\frac{1}{2}}\,L^{\frac{3}{2}}\,T^{-1}$, and this is the dimensions of a static charge of electricity.

But when we turn to dynamic electricity, or electricity in motion, we can no longer handle and deal with quantities of it we can only treat it in currents. This dynamic electric force will therefore be something dependent on a current.

We have seen that currents flowing in the same direction attract one another, and it is experimentally found that if any single portion of the current be considered, the attractive forces vary as the product of the current-strengths, multiplied into the lengths of the conductors through which the currents are passing, and also inversely to the square of the distance which they are apart; that is to say, that if two currents C, C′, running along wires of length 1 1′ are a distance L apart, the force between them will be $\frac{C \times 1 \times C' \times 1'}{L^2}$. And as before, we must make this of the dimensions of a force, viz., $\frac{M\ L}{T^2}$. But this involves (by similar reasoning) the making C of the dimension $M^{\frac{1}{2}}\ L^{\frac{1}{2}}\ T^{-1}$.

But the quantity of electricity that flows in a current in a given time is found by multiplying the current strength by the time, that is to say $Q = C\ T$. Whence Q is of the dimensions $M^{\frac{1}{2}}\ L^{\frac{1}{2}}$. Hence result of the making of these electrical forces of the dimensions of a force is that for static electricity one unit of quantity has the dimensions $M^{\frac{1}{2}}\ L^{\frac{3}{2}}\ T^{-1}$; and for dynamic $M^{\frac{1}{2}}\ L^{\frac{1}{2}}$; or, in other words, the static unit is related to the dynamic in the ratio $\frac{L}{T}$ that is, a velocity.

This has led to the inference, that if velocity be imparted to quantities of static electricity, it would cause them to attract and repel one another, independently of their statical attractions and repulsions, a hypothesis propounded by Clerk Maxwell, and verified experimentally by Rowland.

To determine the velocity which serves as a link between the units of quantity in the static and dynamic systems, a measured quantity Q of static electricity is allowed to escape to earth and form a current, which is measured, and found to be C, from this Q can be calculated in dynamic measure, and it is found to be a small fraction of the static quantity Q. The ratio between them is 29,857,000, which represents the velocity above spoken of in centimetres per second.

Now this happens also to be the velocity of light, whence it is supposed that light is only some form of electro-magnetic disturbance.

The following are the dimensions of the dynamic electrical units, which are called the Absolute, or C. S. G. units.

Current strength	$M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$
Quantity	$M^{\frac{1}{2}} L^{\frac{1}{2}}$
Electromotive force	$M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-2}$
Resistance	$L T^{-1}$
Capacity	$L^{-1} T^{2}$

It will be noticed that in the above system, by taking the attraction between two quantities, as of the dimensions of force, that R, the resistance of a conductor, has come out as a *velocity*, a rather curious result.

These theoretic units having been taken, we can determine the value in terms of them of various concrete electrical quantities. Thus, let it be required to find the length and size of a piece of pure copper wire which would have a resistance of one unit. To do this, we cause a given piece of copper wire to be rotated in a field of magnetic force. The earth's field, from its uniformity, is always selected. By observing the current generated in the copper wire, at a given velocity, we can calculate the velocity at which it must be rotated in order to produce in a field of unit force, a unit of current. This, again, gives the resistance of the wire. The C. S. G. unit of resistance so found is, however, so small as to be inconvenient, wherefore for convenience we take a new practical unit, of 1,000,000,000 C.S.G. units, and this new practical unit is called the "ohm." As has been said before, the ohm resistance is about that of a copper wire 960 feet long, and .1 inch diameter. In like manner, and by other methods, the volt (or practical unit of electromotive force) (taken at 100,000,000 absolute units), and the ampère (or practical unit of current strength), taken at one-tenth of an absolute unit, are determined.

The above resistance is for *pure* copper wire. In practice the commercial copper wire usually obtained is very bad, being often upwards of fifty per cent. under its conducting power. For the slightest impurity is very detrimental.

INDEX.

PAGE
- Above-ground Works, restrictions as to . . . 27
- Accidental Damage to Electric Works . . . 59
- Accounts to be stated yearly by undertakers . . . 23
  - of local authorities . . . 22
  - audit of. (Schedule) . . . 41
- Accumulators . . . 275
- Act of Parliament, provisional order confirmed by . . . 18
  - (*See* General Act, Special Act.)
- Advertisements (provisional orders) . . . 6, 16, 78
  - specimen advertisement . . . 154
  - deposition of copies of . . . 7, 76, 80
  - proof of publication of advertisements . . . 9, 78, 90
  - proof of deposition of . . . 9, 76, 91
  - advertisements (licenses) . . . 13
  - proof of publication of . . . 14
  - form of . . . 154
- Agreement, acquisition of lands by . . . 25
- Alteration of wires and pipes (procedure as to) . . . 111
  - of electric lines . . . 50
  - of telegraph lines . . . 66
- Alternation of Currents, limits of . . . 125
  - disadvantages of . . . 280
- Aquarium, electric light at . . . 217, 235
- Annual Report by Board of Trade . . . 37
- Arc, electric . . . 239
- Arbitration. (*See* Board of Trade Arbitrations.
  - general provisions as to . . . 36
  - compensation for damage . . . 17, 110
  - compensation to owners; of canals, &c. . . . 28
  - disputes as to proper use of electricity . . . 29
  - where Postmaster-General is concerned . . . 34
  - purchase of undertaking by local authority . . . 35
  - expenses of . . . 63
- Area of Supply . . . 3, 15, 16, 94
  - extension of and alterations in . . . 102
- Arrears of Rent, incoming tenant not liable for . . . 61
- Assessments, police or burgh (Scotland) . . . 43
- Assignment of powers under Act forbidden . . . 24
- Audit of Accounts . . . 41
- Ayrton and Perry's ammeter . . . 262
  - ,, ,, meters . . . 268

PAGE
BATTERY, nature of 172
BOARD OF TRADE may grant licenses 16
  ,, ,, provisional orders 18
  ,, make, alter, and amend rules for mode of application to 19, 75
  ,, ,, regulations to be inserted in orders and licenses 20
  ,, ,, regulations for public safety . . 20, 139
  ,, order local inquiries 62, 79
  annual report by 37
  orders of may be in writing 64
  official documents issued by 75-97
  approval of bye-laws of local authority 21
  approval of, how signified 146
  revocation of provisional order by 17, 20, 119, 144
  order arbitrations. (*See* Arbitrations.)
BOARD OF TRADE ARBITRATIONS ACT 36
  printed at page 62
BOROUGHS, audit in 42
BORROWING BY LOCAL AUTHORITY. (*See* Local Authority) . . . 22
  schedule, to Electric Lighting Act 41
BOYS' METERS 263
BREAKING UP STREETS. (*See* Street.) 49
BRIDGES, breaking of soil of 49
BRUSH DYNAMO 219
BURGIN-CROMPTON MACHINE 223
BYE-LAWS, as to safety, made by local authority 21
  confirmed by Board of Trade 21
  alteration of wires, to be subject to 28

CANALS, clauses for protection of 28
  List of, to be deposited 8, 12
CAPITAL, how to be provided by undertakers 95
  separate capital to be provided 104
  increase of capital 105
  statement of to be deposited 8, 12
CHARGES FOR ELECTRICITY. (*See* price) 150
CHARGING MAIN, defined 101
  potential, and insulation of 141
CHEMICAL ACTION used to produce electricity 171
CITY OF LONDON, borrowing of money by 22
  the local authority for 41
CIVIL DEBTS, penalties to be recovered as 25
CLERK OF THE PEACE, deposition of maps with 77
COMMISSIONERS OF SEWERS, local authority for City of London . . 41
COMPANY (defined) 38
COMPENSATION to owners, &c. 28, 29
  for damage 50
  to Postmaster-General 68
COMPULSORY WORKS 4, 118
  compulsory supply. (*See* Supply.)
CONDUCTORS, mode of arranging 250
CONSENT OF BOARD OF TRADE to assignment of powers 24
  to breaking up of streets 27

PAGE
Consent of Grand Jury in Ireland, mode of expression of . . . 40
Consent of Local Authority to application for license . . 6, 12, 16, 77
  to construction of overhead works 27
  how proved 77
Consent of Private Owners 54
  of local authorities 13, 81
Consent to Loans. (Schedule) 41
  contributory place 46
Cost of Electric Lighting 270
Current, maximum current to consumers 132
  maximum current to be sent through service lines . . . 140
  produced by magnets 182
Cutting off Supply 31, 57
Crown, rights of, saved 5, 147

Damage, undertakers to do as little as possible 29, 50
  wilful damage to electric works 58, 60
  summary of provisions as to damage, &c., to electric works . . 32
  to lines of Postmaster-General 33
Damages, recovery of 59
  undertakers to be responsible for 147
Daniell's Cell, used as a measure of E.M.F. 173
Dedication of Highway 51
Distress, meters, &c., not subject to 33, 57
Distributing Main 101
Docks and Basins, protection of 28
Drum Armature Machines 229
Dynamos, general nature of 196
  pole armature machines 205
  ring armature machines 209
  drum armature machines 229

Earth Connexions forbidden 139
Easements included in definition of land 25
Edison's Machine 232
  incandescent lamps 245
  meter 258
Electricity defined, Electric Lighting Act, secs. 2, 52 . . . 15, 38
  may be used as consumers please 29
  nature of electricity 166
  frictional electricity 170
  cost of 150, 271
Electric Lines defined 38
  laying of 49
Electric Lighting Act, 1882 15
  table of, sections of. (*See* Table of Contents.)
  title of, sec. 1 15
  application of Act 16
Electro-Magnetism 178
  direction of currents produced by magnets 182
Electromotive Force (or pressure) 5
  limits of 141
  nature of 172

PAGE
Electro-Motors . . . 254
  Siemens' Tramway . . . 255
Elphinstone-Vincent Machine . . . 236
Energy of a Current . . . 174
Expenses of Board of Trade . . . 36, 63
Expenses of Local Authority. (*See* Local Authority) . . . 21

Faure-Sellon-Volckmar's Accumulators . . . 275
Fees payable on presenting memorial . . . 77
Ferranti-Thompson Machine . . . 234
Force, nature of . . . 168
Forms—1, notice to local authority of intention to apply for a provisional order 153
  2, notice convening a meeting . . . 153
  3, resolution of local authority . . . 154
  4, advertisment in newspapers . . . 154
  5, memorial . . . 156
  6, statement of local authorities of whose area the area of supply will be situate . . . 157
  7, streets, &c., proposed to be broken up . . . 157
  8, canals, &c., to be crossed . . . 157
  9, capital to be employed . . . 157
  10, certificate of passing of resolution . . . 157
Fraudulent use of Gas (electricity) . . . 58

Galvanometers . . . 261
"Gas," to be read "electricity" &c. . . . 25
  cost of, as compared with electricity . . . 271
Gas Engines . . . 256
Gas Undertakers, relieved from liability . . . 37
Gasworks Clauses Act, 1847 . . . 24, 25
  provisions of, note (2) . . . 26
  sections of, printed . . . 49
Gasworks Clauses Act, 1871 . . . 24, 25
  provisions of, note (3) . . . 26
  sections of, printed . . . 60
Gaulard and Gibbs' Induction Coils . . . 278
General Acts of Parliament, undertakers not exempt from . . . 39, 148
"General Supply" defined . . . 101
Gordon's Dynamo . . . 206
Gramme Ring, principles of . . . 209
  dynamos . . . 214
Gulcher Dynamo . . . 227

Highway, nature of, and how dedicated . . . 51
  by whom repairable . . . 52
Highway Authorities, England . . . 47
  Ireland . . . 40
  Scotland . . . 48
Holborn Viaduct, Electric Lighting Act . . . 232

Incandescent Lamps . . . 240
  mode of manufacture . . . 243
  Swan's . . . 244

PAGE
Incandescent Lamps, Edison's . 245
  Lane-Fox's . 247
  Maxim's . 247
  Woodhouse and Rawson's . 248
Indictment, undertakers not exempt from . 148
Induction, magnetic . 160
  dynamic electric . 279
Induction Coils . 278
Injuriously affecting Electric Lines of Postmaster-General (definition) 34
Injury to Electric Works. (*See* Damage) . 32
Inquiries . 20, 127
  local inquiries . 62
  Act of 1872 repealed . 64
  into conditions of mains, &c . 144
  made to relieve gas undertakers . 37
  expenses of . 37, 63
Inspection and Inspectors . 20, 127
  remuneration of inspectors . 127
Insulators . 167
Insulation . 193
Inverse Square, general law of . 162
Ireland, Electric Lighting Act applicable to . 39
Iron, inductive capacity of . 165, 209

Justices not disqualified from acting by liability to gas rent, &c. . 62
  power of, as to breaking up streets . 55

Kabath's Accumulator . 277
Kensington Museum, electric lighting at . 222

Lamps, special forms not to be prescribed . 29
  supply of electricity to public lamps . 132
  charge for the same . 135
  damage to, or extinction of . 58
  arc lamps . 337
  incandescent lamps. (*See* Incandescent.)
Land, definition of, includes easements . 25
  acquisition of . 4
  deposition of description of lands proposed to be purchased, 10, 14, 79, 87, 94
  otherwise provisional order not to be in force . 79
Lands Clauses Acts, secs. incorporated . 24, 25, 72
  defined . 38
Lane-Fox's Incandescent Lamps . 247
Larceny of Electricity . 5, 31
Lead, forward lead of brushes in dynamos . 211
Licenses . 2, 16
  nature of . 4
  procedure for obtaining . 11, 16, 75
  application by memorial . 12, 77, 83, 156
  deposition of copies of draft license . 12
  entertainment of application for . 12
  proof of consent of local authorities . 13, 81
  proof that draft license is in proper form . 13, 84

PAGE
LICENSES, proof of supply to public of copies of, at 1s. 14, 85
  granting of licenses by Board of Trade 16
  period of duration of 16
  regulations to be inserted in 17
LIGHT, law of radiation of 162
LINES OF FORCE, magnetic 164
LOCAL AUTHORITY, notice of application for provisional order . . . 6
  proof of notice of application to 9, 18
  obtaining consent of to application for license . . . 12, 16
  when local authority is the applicant 12, 77
  proof of consent of to application for license . . . 13, 81
  may obtain license over area outside their district . . . 17
  may make safety regulations 21
  definition of Electric Lighting Act, secs. 2, 31, 36, and schedule 15, 38, 39, 41
  expenses of, to be defrayed out of rates 21
  may borrow money 22
  may enter into contracts 23
  purchase of concern by 2, 35
  may exercise certain powers of undertakers in breaking up streets 17, 116
LOCAL LOANS ACT, local authority may borrow under . . . 22, 74
LOCAL RATES . . . . 41, *et. seq.*
LONTIN MACHINE 205

MAGNETS 159
  electro-magnets, direction of currents round 179
  horseshoe magnets 181
MAGNETISM, nature of 159
MAINS defined 101
  to be insulated 139
MALICIOUS INJURY TO ELECTRIC WORKS 31
MAPS of proposed area 5
  to be deposed with Clerk of the Peace 7, 12, 14
  proof that this has been done 7, 14
  mode of colouring and scale of 7
  to be deposited after order deposited 122
MAXIM-DYNAMO 226
  incandescent lamps 247
MEASUREMENT OF ELECTRICITY. (*See* meter) 133
  note as to modes of measurement 134
  on units of measurement 281
MEMORANDUM OF FEB. 26TH 94
MEMORIAL TO THE BOARD OF TRADE for a provisional order 7
  lodging of 75, 77, 91, 156, 157
  proof of lodging of 9, 75, 91
MEMORIAL TO THE BOARD OF TRADE for a license 7
  application by 12, 77, 83, 156
  proof of lodging of 13, 83
METERS 5
  powers of undertakers to let meters 57, 137-139
  meters to be used 135

PAGE

METERS, to be certified, fees for same . . . 136
  obligation on undertakers to supply meters . . . 136
  not to be disconnected without notice . . . 137
  consumers to keep meters in order . . . 137
  inspection of meters . . . 137, 138
  expenses of providing meters . . . 138
  undertakers may put check-meters on lines . . . 139
  general principles of construction of . . . 257
  chemical action meters . . . 258
  mechanical meters . . . 259
  Boys' meters . . . 263
    ,, energy meter . . . 263
    ,, vibrating meter . . . 265
  Hopkinson's meter . . . 267
  Ayrton and Perry's meters . . . 268
METROPOLIS MANAGEMENT ACT, 1855 . . . 41, 73
METROPOLITAN BOARD OF WORKS, districts lit by . . . 41, 46
  borrowing by . . . 22
MINES, owners of protected . . . 38
MONOPOLY, not created by Act . . . 2, 96
MORTGAGES by undertakers . . . 147

NEEDLE, magnetic, positions taken up by . . . 161, 163
NOTICES, how to be served by undertakers . . . 61, 143
  how to be served on Postmaster-General . . . 71
  how to be served on Postmaster-General and to local authorities . 108
  to gas, water, and telephone companies . . . 114
  of approval of Board of Trade, how given . . . 146
  of applications for extensions of time, how given . . . 146
  of intention to break up street . . . 54
  to Postmaster-General . . . 66, 71
  of intention to alter pipes, wires, &c., in order to lay electric works . 111

OBJECTIONS, to be heard . . . 10, 17
OBSTRUCTION TO LINES OF POSTMASTER-GENERAL, penalty for . . . 69
OFFENCES UNDER THE TELEGRAPHS ACT, how prosecuted . . . 69
OHM'S LAW . . . 177
OVERHEAD WIRES, restriction as to . . . 27
  their danger . . . 27

PENALTIES for delay in reinstating streets . . . 55
  to be recovered as civil debts . . . 25
  recovery of . . . 59, 146
PIPES may be altered by undertakers . . . 28
  laying of (electric wires) . . . 49
POLARITY . . . 159
POLES OF THE EARTH . . . 161
POLE ARMATURE MACHINES . . . 205
POLES ON CONSUMERS' PREMISES to be three inches apart . . . 140
  number of poles to be provided . . . 140
POLICE COMMISSIONERS IN SCOTLAND . . . 43
POSTMASTER-GENERAL, definition of . . . 70
  his electric lines . . . 34, 65
  his privileges saved . . . 39

PAGE

PRESSURE. (*See* Electromotive Force.)
pressure on the parallel system regulated 123
limits of standard pressure 124, 141
precautions to be taken when pressure exceeds 200 volts . . 140
PRICE OF ELECTRICITY 5
regulations as to 20, 133-135, 150
no undue preferences allowed 30
ultimately to be charged by meter 96
methods of charging 133
maximum prices 135
PRIVATE PURPOSES 5, 16
PRIVATE SUPPLY OF ELECTRICITY unaffected 1
PRIVATE LAND not to be entered on without consent 50
PROCEDURE for obtaining provisional orders 6-11, 78
for obtaining licenses. (*See* also Provisional Orders, Licenses) 11-14, 78
PROMOTERS. (*See* undertakers) 24
PROOFS, preparation and lodging of for provisional orders . . . 8
,, ,, ,, ,, licenses 13
forms of proof of due compliance with requirements of Board of Trade 81-94
PROVISIONAL ORDER 2
nature of 4, 18
procedure in obtaining 6, 18, 75
deposition of copies of 8
proof that proposed provisional order is in due form . . . 10
supply of copies to public at 1s. 10, 92
objections to 10, 62, 78
no force till confirmed by Parliament 18
nor till list of lands to be purchased has been deposited . . 79
may be granted by Board of Trade 18
Chelsea Provisional Order 98-152
provisional orders obtained by local authorities 151
PUBLIC HEALTH ACTS 46, 48, 72
Scotland 72
Ireland 73
PUBLIC PURPOSES 16, 18
PURCHASE OF UNDERTAKING by local authority 2, 35

RAILWAY COMMISSIONERS, reference of disputes to 64
RAILWAYS not to be broken up unless by consent or under special powers . 27
RECOVERY OF CHARGES. (*See* Damages, Penalties, Civil Debts) 5, 31, 57, 61
damages and penalties 59
REFORM CLUB, electric lighting at 236
REINSTATEMENT OF STREETS 55, 56
RENTS, recovery of 5, 31, 57
RESISTANCE (electrical) 175
table of resistances 178
of human body 194
RESOLUTION of local authority to apply for license or order . . 6,17
proof of 9, 157
REVOCATION OF POWERS 17, 20, 119, 144
RING ARMATURE MACHINES 209
ROYAL COURTS OF JUSTICE, electric lighting at 223

PAGE
Rules of the Board of Trade, October, 1882 . . . 75
    to be judicially noticed . . . 19
Rural Sanitary Authority . . . 42

Safety, regulations of Board of Trade as to . . . 20, 139
Safety Plugs or Fuses, to be used . . . 140
    mode of construction of . . . 253
Sanitary Districts . . . 42, 44, 45
    note as to . . . 46-48
Savoy Theatre, electric lighting at . . . 232
Schuckert Dynamo . . . 228
Scotland, Electric Lighting Act applicable to . . . 39
Sewers, opening of . . . 49
Security to be given by undertakers . . . 104
    ,, ,, consumers . . . 145
Service Line defined . . . 101
    to be of pattern approved by Board of Trade . . . 139
    maximum current to be sent through . . . 140
Sheriff's Clerks (Scotland), deposition of map with . . . 77
Shocks . . . 126, 194
Shunt . . . 192
Siemens' Dynamos . . . 229
    electrical tramway . . . 255
Special Act (definition of) . . . 24
Special Acts, limits of, defined . . . 25
    meaning of in Board of Trade Arbitration Act . . . 63
Stealing Electricity. (*See* theft) . . . 31
Steel, magnetic nature of . . . 160
Stock may be issued by local authority . . . 22
Storage of Electricity . . . 275
Streets, public and private . . . 4, 52, 111
    defined . . . 38, 49
    breaking up of by local authority . . . 17, 116
    restrictions on breaking up of private streets . . . 27, 49, 50
    superintendence of . . . 55
    defined in Telegraph Act, 1878 . . . 65
    procedure as to breaking up streets not repairable by local authority 109
Summons or Warrant under the Act may contain more than one name . 61
Superintendence over breaking up of streets . . . 55
Supply of Electricity to be regular and efficient . . . 17, 20, 130
    nature of supply . . . 130-133
    obligation to supply electricity . . . 30, 130
    modes of supply . . . 95, 106
    time of supply . . . 96
    supply on the parallel system, regulations as to . . . 123
    to be delivered at two poles on consumer's premises . . . 125
    maximum current . . . 132
    penalty of failure to supply . . . 132
    to be capable of being turned off outside consumer's premises . 140
Standard Pressure. (*See* pressure) . . . 124
Swan's Incandescent Lamps . . . 244

Telegram defined . . . 38

PAGE
TELEGRAPH ACTS defined 65
  1878 33
  printed at page 65
TELEGRAPH LINES OF POSTMASTER-GENERAL, provisions as to . . 65-71
  not to be altered except as provided 33
TELEPHONE COMPANIES, protection to 115
TESTING ELECTRICITY 127
  expenses of testing 128
  instruments to be provided and kept 129
THEFT OF ELECTRICITY 5, 31
THOMPSON, Sir W., his galvanometers 261
TOWN COUNCILS for Burghs in Scotland 43

UNDERTAKERS 1
  general powers of 23
  definition of 24, 66
  powers of to contract for supply of electricity . . . 56
  ,, ,, to let meters 57
  may enter lands to ascertain electricity consumed . . . 57
  may be relieved from obligations as to safety 142
UNDUE PREFERENCE. (*See* price) 30
UNDUE USE OF ELECTRICITY 29, 58
UNIT OF ELECTRICITY, as defined by Board of Trade 149
URBAN SANITARY AUTHORITY 42

VOLT, measure of electromotive force 174
VOLT-METERS, principles of 262

WATERPROOF COVERING to wires 139
WATT, measure of electrical power 174
WESTON DYNAMO 226
WIRES may be altered by undertakers, in order to execute their works . 28
WOODHOUSE AND RAWSON'S INCANDESCENT LAMPS 248
WORKS defined 38
  to be executed 107

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